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GEOLOGICAL SURVEY OF KENTUCKY.

JOHN R. PROCTER, Director.

CHEMICAL ANALYSES.

A

VOL. II.

FOURTH, FIFTH, AND SIXTH CHEMICAL REPORTS, AND COMPARATIVE VIEWS OF THE COMPOSITION OF SOILS, COALS, ORES, LIMESTONES, CLAYS, MARLS, MINERAL WATERS, ETC., ETC.

BY ROBERT PETER, M. D., ETC., ETC., CHEMIST TO THE SURVEY, AND A. M. PETER, ASSISTANT.

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GEOLOGICAL SURVEY OF KENTUCKY.

JOHN R. PROCTER, DIRECTOR.

CHEMICAL REPORT

OF THE

SOILS, COALS, ORES, CLAYS, MARLS, MINERAL WATERS, ROCKS, &C.,

OF KENTUCKY,

BY ROBERT PETER, M. D., ETC., ETC.,

CHEMIST TO THE SURVEY.

THE FOURTH REPORT IN THE NEW SERIES AND THE EIGHTH SINCE THE BEGINNING OF THE GEOLOGICAL SURVEY.

PART XIII. VOL. V. SECOND SERIES.

STEREOTYPED FOR THE SURVEY

INTRODUCTORY NOTE.

CHEMICAL LABORATORY OF KENTUCKY GEOLOGICAL SURVEY,
LEXINGTON, KY., June 10, 1879.

Prof. JOHN R. PROCTER, *Director of Kentucky Geological Survey:*

DEAR SIR: Herewith I respectfully submit to you the results of the chemical work performed in this Laboratory for the Geological Survey since the publication of my last report.

Yours, &c.,

ROBERT PETER.

CHEMICAL REPORT.

Of the one hundred and fifty-two new analyses reported on the following pages, there are of—

Soils, subsoils, and under-clays	90
Clays and marly clays and shales	25
Limestones	13
Waters	8
Iron ores	6
Coals	5
Silicious residues of soils	5

The soils examined show, as usual, a great variety of composition, as may be seen in the following table of their extremes of variation:

	(*a*) Pr. cent.	No.	County.	(*b*) Per cent.	No.	County.
Organic and volatile matters vary from	9.305	in 2123	from Fulton	to 1.840	in 2212	from M'Cr'k'n
Alumina and iron and manganese oxides vary from	14.368	in 2215	from Nelson	to 2.932	in 2112	from Clinton.
Lime carbonate varies from	2.485	in 2206	from Madison.	to .070	2212 and 2252	McCracken and Wayne
Magnesia varies from	.989	in 2206	from Madison.	to .052	in 2221	from Pulaski.
Phosphoric acid varies from	.387	in 2206	from Madison	to .029	in 2253	from Wayne.
Potash extracted by acids varies from	1.097	in 2154	from H'nd'rs'n	to .021	in 2253	from Wayne.
Soda extracted by acids varies from	.657	in 2215	from Nelson	to traces	in several.	
Water expelled at 380° F. varies from	3.110	in 2123	from Fulton	to .420	in 2153	from H'nd'rs'n
Sand and insoluble silicates vary from	76.715	in 2206	from Madison.	to 94.590	in 2253	from Wayne.
Water expelled at 212° F. varies from	4.104	in 2123	from Fulton	to .444	in 2253	from Wayne.
Potash in the insoluble silicates varies from	2.742	in 2215	from Nelson	to .327	in 2112	from Clinton.
Soda in the insoluble silicates varies from	1.208	in 2099	from Ballard	to .101	in 2110	from Clinton.
Gravel varies from	None	in most	of these soils	to 34.700	in 2220	from Pulaski.

Columns (*a*) and (*b*) give the chemical composition of very rich and very poor soils; but being made up of extremes from the various soils, they do not represent the composition of any one of them. As may be seen by reference, these extremes are not quite so great as those reported in Volume IV and in the first part of this volume of these Reports.

Summing up all the soil analyses which have been made and reported, by the writer, for the Geological Survey of Kentucky, since its commencement in 1854, under the late David Dale Owen, M. D., to the present time, he finds them to number seven hundred and seventy-two; including soils,

subsoils, and under-clays from eighty-seven counties of the State.

Of these, there were only one sample each from ten counties, two samples each from six counties, and three each from fifteen counties. From twenty-nine counties no samples of soils have as yet been collected. Of those reported in the following pages, nearly one half were collected in the year 1859, from the eastern coal field of our State, by Joseph Lesley, jr., then Geological Assistant in the Survey under Dr. Owen. These specimens of soils, having been carefully preserved in a dry place since the time of their collection, have remained unchanged, and their analyses are interesting, as proving that even in this sparsely settled mountainous region of Kentucky the soil is generally susceptible of profitable cultivation.

It is to be specially noted that, as the greater part of the soils of our State have been produced, in the localities in which they are found, by the disintegration of the superficial rock strata, and are not, like most of the soils of the great territory north and west of us, made up of mixed detritus which has been brought from other regions by the moving force of ice and water, the local character of our various soils is more dependent on that of their rock substrata than in the great territory in question. Hence we generally find our soils to be much richer lying on soft limestone or shaly rock strata than on the hard sandstones or conglomerates of the coal-measure formation Moreover, we find in some of the coal-measure soils a considerable proportion of angular gravel or fragments of soft ferruginous sandstone or sandy-ferruginous concretions; and in some the rounded quartzose pebbles of the millstone grit; while on the extended low plains, called in some parts of the State the "Barrens," because in former recent times they were destitute of trees, the smaller proportion or absence of gravel indicate formation of the soil under comparatively quiet water, by the wash of the finer earthy materials from the adjoining higher lands.

So far as our investigation has been carried, the soils of Kentucky, with the exception of some of those which lie on

the mountain slopes and valleys, especially in the coal-fields, are composed of materials in a state of very fine division; so fine, indeed, that the so-called "sand and insoluble silicates," left after the digestion of the soils in chlorohydric acid (specific gravity=1.1), will pass almost entirely through the fine sieve employed, which has 1,600 meshes to the centimeter square. Nowhere in the State have we found soils containing coarse sand, like some of those in the north or northwest of our continent. Hence, in the examination of our soils, "silt analysis," or the separation of the finer from their coarser materials, so useful when applied to some soils, has not been deemed of great importance, and has been seldom resorted to in the processes used.

This high state of comminution of our soils, by increasing the porosity and extent of surface of their materials, also increases their power of absorbing and retaining the fluid, dissolved solid, or the aeriform materials of plant-food, and greatly improves their fertility. Soils of this character could only be formed under quiet waters, or under water at a distance from its shores, or by the disintegration in place of rock strata which had been deposited under these conditions.

In the process of the analysis of these soils, they were digested for seven to ten days, on the sand bath, at a temperature below boiling, in five times their weight of chlorohydric acid, of specific gravity=1.1, a little nitric acid having been added to decompose the organic matters. In all of the soils reported in this, as well as in the two preceding Chemical Reports, the quantities of potash and soda which remained in the silicious residue, after digestion in these acids, was determined by a separate process, viz: that of ignition with a mixture of calcium carbonate and ammonium chloride, &c., according to the method of J. Lawrence Smith. These quantities, as may be observed by reference to the several analyses, are generally quite considerable.

On comparing the proportions of these two alkalies, severally, in the "sand and insoluble silicates" of the soils above mentioned, in number amounting to more than two hundred

and fifty, we find their extremes to be as follows, calculated into the weight of the original soil:

The percentage of *potash* in the silicious residues varies from 2.910 per cent. in No. 2037, from Harlan county, to 0.327 per cent. in No. 2112, from Clinton county.

The percentage of *soda* varies from 1.208 per cent. in No. 2099, from Ballard county, to 0.018 per cent. in No. 1678, from Bell county.

The general composition of several of these silicious residues, as ascertained by complete analyses, by fusion with the alkaline carbonates, &c., is reported under the heads of Fulton and Nelson counties, to which the reader is referred for proof of the statement frequently made by the writer, that in this silicious skeleton of our soils a considerable proportion of silicates are found, which, while they may resist for a time the action of even moderately strong mineral acids, may yet, by a slow process of natural "weathering," measurably renovate the fertility of the soil from their reserved store of essential mineral elements of plant food.

In what form do these silicates exist in our soils, is a question of some interest. It has been known for some little time that silicates of the Zeolite group are found in soils, and that they perform a very important office in that selective, absorptive power which the soil possesses, by which it can withdraw from watery solutions, and hold for the benefit of growing vegetables, many essential elements of plant nourishment which else would be washed away in the drainage. Such silicates, no doubt, exist in our Kentucky soils; but they are known to be readily soluble in, or decomposable by, acids. It would seem probable, therefore, that the silicates, or the partly-weathered remains of silicates, in the silicious residue of our Kentucky soils, which had, to a certain extent, resisted the prolonged digestion in acids, were more of the nature of the minerals constituting the Feldspar group than the Zeolites.

As has been frequently stated in the reports, this silicious residue of our soils frequently left upon the fine sieve more or less of small particles, sometimes rounded, but often some-

what angular in form, which were generally soft enough to be crushed by the fingers into a powder fine enough to pass through the fine sieve. Until recently, the writer believed that these small particles represented, in their form at least, those silicates in the soil which had undergone a partial decomposition in the acid digestion, and which still retained, in their soft silicious skeletons, some of those alkalies which were found in the silicious residues.

But observing that the proportion of these residual soft particles did not bear any constant relation to that of the alkalies in the silicious residue, he was induced to examine, by washing with water, some of these soils, which left, after digestion in acids, the largest quantity of these so-called "partly decomposed silicates," and he was somewhat surprised to find that, in these soils at least, these soft particles were derived from little concretions in the soil, of the nature of so-called "shot iron ore," which probably had their origin in the infiltration of dissolved oxides of iron and manganese, or of calcium carbonate, or may have been originally oölitic aggregations in the rocks from whence the soils had been derived. Be this as it may, however, the important fact remains, that in the fine sandy or silicious residue of our soils, after prolonged digestion in acids, there exist potash, soda, lime, magnesia, and even a little phosphoric acid, which materials, although held in pretty firm combination as silicates in the insoluble residue, may prolong the productiveness of the soils under the slow decomposing action of the atmospheric agencies. Another fact is, that these silicates are in a state of as minute division in our soils as the fine silicious sand itself.

Of the eighteen new analyses of *Clays* herewith reported, fourteen are of clays from the tertiary formation, and one from the quaternary of the southwestern extremity of Kentucky, called the "Jackson Purchase." Three are from the Lower Silurian formation in Madison county.

The *tertiary deposits* of the first-mentioned region show considerable variety in their composition and properties. Some

are highly silicious or sandy; some are quite calcareous; and others, containing more alumina, exhibit different varieties of clay, some being of the nature of good fire-clay. Those which contain a considerable proportion of silicious matter, some of which may be in the form of fine sand, and which contain but small quantities of iron oxide, lime, potash, or soda, deserve a trial as glass-pot clay, provided they are sufficiently plastic, or burn sufficiently hard. Others may be available as fire-clay for many other purposes, and several would answer well for the manufacture of different sorts of pottery-ware, terra-cotta, drain-tiles, bricks, &c., according to their nature.

Some of these beds, their material being in a finely-divided state and friable, might be made useful in the manufacture of artificial hydraulic cement, of the character of Portland cement, whenever such an industry may be profitable in this region. Some of these deposits are so highly quartzose that they could be employed in the manufacture of glass. The "loess" from the quaternary may be locally useful as a top-dressing on heavy clay soils, &c.

The *clays* reported from Madison county are too readily fusible to be used as fire-clays, yet are good plastic clays for the manufacture of hard stoneware or some forms of terra-cotta, &c. The marly clays and shales from the Silurian limestone strata are remarkable for their large proportions of potash; the one from the Lower Silurian in Fayette county giving nearly eight per cent. of that alkali. They also have considerable quantities of lime, iron oxide, &c., and no doubt all contain phosphoric acid, so that their use as fertilizing top-dressing on exhausted light soils might be locally beneficial. They are too fusible for some kinds of pottery, yet might be made into drain-tiles and similar products, or, in some cases, into stone-ware.

The thirteen *limestones* reported in the following pages are mostly from Madison county; one only from Franklin county; and are interesting mainly because the composition of several of them indicates their probable availability for the manufacture of *hydraulic cement.* It is true that imperfect trials made

of some of these, in the laboratory, with insufficient appliances, did not give decidedly favorable results in this relation; yet, probably, by a more perfect mode of calcination, adapted to their nature, the hydraulic properties might be developed.

For the purpose of comparison, the writer has appended to the table of the composition of these limestones, at the end of this Report, that of two undoubtedly good hydraulic limestones, copied from previous volumes of Reports of Kentucky Geological Survey.

It seems, however, that although we may learn much from the ultimate chemical composition of limestones, as to their availability for hydraulic cements, there are some necessary conditions to the production of these useful compounds not yet fully understood or appreciated, as is proved by the circumstance that while two different limestones may show, by analyses, nearly similar chemical compositions, they may yet give products, when calcined, which differ greatly in their value as hydraulic cements.

These conditions may possibly be physical, or what is more probable, the silica in the two limestones may be under different chemical relationships. Probably the impure limestone, which gives the best cement by calcination, has its silica already more or less naturally combined with lime or other bases, as silicates or hydrated silicates; while in the other, of similar ultimate composition, the silica may be more in a separated, insoluble state, or in firmer combination with other elements. This supposition is rendered probable by the fact that there are natural hydrated silicates which possess, to an eminent degree, the property of forming good hydraulic cements by simple mixture with pure quicklime and water. The best known of these, the volcanic tufa found near Naples, called Pozzuolana, is found to contain a large proportion of soluble silica in the form of hydrated silicates; and it has been found by experience, that when the water of its silicates is driven off by calcination, it loses its valuable hydraulic properties. Most of these Pozzuolanas contain a considerable proportion of alkalies, varying from more than one to about ten

per cent., and in the artificial compounds of this kind made by calcining certain marly clays, at a heat sufficient to burn lime, it is probable that the well-known large proportion of alkalies generally found in these clays is essential in bringing the silica into a soluble condition.

It is now pretty generally acknowledged by men of science that the property of hardening under water depends on the presence or formation of silicate of lime in the cement. In this connection it may be well to observe, that in the analysis of the hydraulic limestone from Indiana, No. 1068, referred to above, it was found that as much as three per cent. of silica, soluble in a boiling solution of carbonate of soda, was contained in this uncalcined limestone. This amount of silica undoubtedly existed in the rock, in the form of silicate easily decomposable by acids, having been separated by the acids in the soluble or gelatinous form. After the calcination of this limestone, the proportion of the soluble silica was increased to more than fourteen per cent. of the calcined rock. In some of the Ohio Falls hydraulic cement, which had been hardened under water about twenty-eight years before it was analyzed by the writer, he found more than six per cent. of the silica yet in a soluble condition. (See Vol. IV, O. S. Ky. Geol. Reports, p. 190.)

As the property of hardening under water seems to depend on the formation of a silicate of lime, probably also sometimes of silicates of magnesia or of iron, the essential conditions for hydraulic lime are not only the presence of a sufficient amount of silica to form the hard compound which resists the solvent action of water, but also that the silica should be in a form favorable to its combination with the lime or other bases, as well as, most probably, the presence of substances which, like the alkalies, may aid in bringing about this combination. The alkalies, potash, and soda seem to be the best agents in promoting this action, and it has been found by experience, in the manufacture of the celebrated artificial Portland cement, by calcining a mixture of chalk and clay, that the addition of a half to one per cent. of soda is greatly beneficial. Magnesia also seems to exert a favorable action; indeed, some mag-

nesian limestones, which contain but a small proportion of silica, make good hydraulic cement, if calcined at a moderate red heat only; and most of our hydraulic limestones are magnesian. Pure calcined magnesia, one of the most insoluble of the earths, will set quite hard with a proper quantity of water. It is probable, as already hinted, that the oxide of iron may be useful in hydraulic cements, by increasing their hardness and durability, as may also alumina.

In the manufacture of the artificial Portland cement, a mixture of impure carbonate of lime, chalk, and clay from various sources, is finely powdered and intimately blended, and then calcined at a heat sufficient to cause a commencement of vitrification; and the best proportions are found to be from twenty-one to twenty-three of clay to seventy-nine to seventy-seven of chalk. Clay from different localities varies in its proportion of silica as much as from less than fifty to nearly eighty per cent., causing variations in the properties and value of the cement.

A very good cement, of the kind employed at Boulogne, France, is reported to have the following *composition:*

Lime	65.00
Magnesia	trace.
Alumina and iron oxide	8.70
Alkalies	.45
Silica	24.45
Water	.80
	99.40

It is generally said, that if the proportion of lime falls below 39.8 per cent.—equal to 70 per cent. of carbonate of lime in the uncalcined mixture—the obtained cement may harden quickly, but will not be durable.

Another very good artificial cement of this kind, reported by scientific writers, is that made by M. St. Leger, near Paris, France, by calcining an intimate mixture of the chalk of Meudon with 14.3 per cent. of the clay of Vannes. The composition of this, after burning, is reported to be—lime, 75.60; silica, 15.86; alumina, 7.93, and iron peroxide, 1.62 per cent. It is said to be wholly soluble in acids.

These remarks and quotations may aid in estimating the probabilities of the utility of our impure limestones, &c.

BALLARD COUNTY.

SOILS AND SUBSOILS.

No. 2096—SOIL LABELED "*Top soil from the 'Barrens;' four years in cultivation in tobacco, three years in corn, and four in wheat; the last and present year* (1878) *in tobacco. Farm of W. H. Reeves, about six miles north of Blandville.*" *Collected by John R. Procter.*

The dried soil is in friable lumps, of a dirty yellowish-brown color. The coarse sieve* separated a few soft, ferruginous concretions and a small quartz pebble.

No. 2097—"*Subsoil of the field above described. Sample taken twelve to eighteen inches below the surface.*" *Collected by John R. Procter.*

The dried subsoil is in friable clods; its color is somewhat lighter than that of the preceding. The coarse sieve removed from it only a few small, rounded ferruginous concretions.

No. 2098—"*Subsoil of the uplands around Blandville. Taken from eighteen to twenty-four inches below the surface. Characteristic of most of the upland subsoil in the Jackson Purchase. A silicious loam above the Paducah gravel.*" *Collected by Jno. R. Procter.*

The dried subsoil is in pretty firm lumps, of a handsome brownish-buff or ochreous color, mottled with lighter and darker tints. All passed through the coarse sieve.

No. 2099—"*Subsoil or under-clay of the uplands around Blandville. Taken several feet below the surface. It crops out just below the gravel bed, and is several feet thick. It is observed nearly all over the 'Jackson Purchase' where there is much soil.*" *Collected by John R. Procter.*

The dried subsoil is of a brownish-buff color, mottled with somewhat lighter colored, and showing some thin, dark-colored

* The coarse sieve used has about 64 meshes to the centimetre square.

infiltrations of iron and manganese oxides. All of it passed through the coarse sieve.

No. 2100—"*Virgin soil. Top soil of bottom land, near Shelton and Moore's Mill, on Mayfield creek. Said to produce good hay, but to be otherwise unproductive. Primitive growth, black, white, and red oak, sweet gum, elm, persimmon, and hickory.*" *Collected by John R. Procter.*

Dried soil of an umber-grey color, in quite friable clods, apparently containing much fine sand. The coarse sieve removed from it only a few small, partly-rounded quartz particles.

No. 2101—"*Top soil from an old field long in cultivation. Bottom land, on Mayfield creek.*" *Collected by John R. Procter.*

The dried soil is slightly lighter colored than the preceding, and more yellowish. The coarse sieve removed only a few small silicious particles.

No. 2102—"*Subsoil of the next preceding. Bottom land on Mayfield creek.*" *Collected by John R. Procter.*

Clods more firm than those of next preceding, and lighter colored, mottled with lighter colored and ochreous tints. The coarse sieve removed from it a small quantity of small silicious gravel.

COMPOSITION OF THESE BALLARD COUNTY SOILS, DRIED AT 212° F.

	No. 2096	No. 2097	No. 2098	No. 2099	No. 2100	No. 2101	No. 2102
Organic and volatile matters	4.065	2.790	2.185	1.565	3.210	2.565	2.125
Alumina & iron & manganese oxides	5.904	7.597	8.357	7.835	6.150	3.864	5.088
Lime carbonate	1.095	.295	.195	.645	.155	.385	.245
Magnesia	.394	.308	.544	.601	.268	.163	.184
Phosphoric acid (P_2O_5)	.246	.093	.093	.140	.115	.061	.077
Potash, extracted by acids	.289	.449	.131	.175	.203	.319	.276
Soda, extracted by acids	.242	.148	.653	.309	.364	.362	.129
Water, expelled at 380° F.	.935	.760	.450	.435	1.065	.635	.675
Sand and insoluble silicates	87.120	87.395	87.110	87.495	88.890	92.010	91.570
Total	100.292	99.835	99.918	99.200	100.420	100.364	100.369
Hygroscopic moisture	2.000	2.300	2.735	2.300	1.865	1.075	1.125
Potash in the insoluble silicates	1.619	1.482	1.085	2.138	1.659	1.358	1.401
Soda in the insoluble silicates	.680	.674	.536	1.208	1.150	.616	.911
Character of the soil	Surface soil.	Subsoil.	Subsoil.	Subsoil or under-clay	Virgin soil	Old field soil	Subsoil.

Some differences were observed in the silicious residue or sand and insoluble silicates of these several soils, when sifted with fine bolting-cloth, which had about 900 meshes to the centimetre square. For example, while that of Nos. 2096, 2097, 2098 all passed through except very few small hyaline or reddish quartz particles, Nos. 2099 and 2100 left upon the bolting-cloth a considerable proportion of small particles of partly decomposed silicates or concretions; the silicious skeletons, as it were, of these substances, from which most of their soluble ingredients had been removed by the acids in which they had been digested, were generally so soft as to be easily crushed under the finger; after which crushing, they readily passed through the bolting-cloth. The bolting-cloth also separated from them a few small quartzose particles, hyaline, opake, and reddish. No. 2101 left none of these soft remains of decomposed concretions on the bolting-cloth, but a few small quartzose particles; while No. 2102 gave a few of these soft, partly-decomposed particles, and rather more of the small quartzose granules than the next preceding soil.

These Ballard county soils, if well drained, no doubt are good productive soils under good management. In all of them, however, except, perhaps, No. 2096, the proportion of organic and volatile matters is quite small, and this, as might be expected, is particularly to be noticed in the deep subsoil or under-clay, No. 2099; but this deficiency might be supplied by the culture of clover or other green crops, to be plowed under after or without grazing. They all contain enough of lime and magnesia, as well as of potash and soda; some of them, indeed, contain more than the average proportion of these essential alkalies, not only in a condition to be immediately available for plant nourishment, but also as a considerable reserve in the insoluble silicates. Nos. 2097, 2101, and 2102, containing but a moderate proportion of phosphoric acid, would no doubt be greatly increased in fertility by the use of phosphatic fertilizers, such as ground bone, superphosphate, guano, &c. Nos. 2101 and 2102 contain more than the average proportion of fine sand and insoluble sili-

cates, and but a small quantity of alumina, &c., &c., and consequently may be less durable naturally than some of the others; but the state of very fine division of their silicious constituents compensates, measurably, the paucity of the clay ingredients. The so-called "barrens" soil is one of the richest of them all.

CLAYS OF BALLARD COUNTY.

No. 2103—"*Ochreous Clay, from southern part of Ballard county.*" *Collected by John R. Procter.* "*Will it make a good and durable paint? Found in several parts of this county.*"

In friable lumps of a yellow ochre color, with some little infiltration of whitish material. It becomes soft and plastic when placed in water. Mixed up with a large quantity of water, and allowed to stand at rest for a few minutes, a portion of fine sand, equal to about twenty-six and a half per cent., settles to the bottom of the mixture, while the ochreous material remains suspended in the water for a considerable time in consequence of its fine state of division.

This fine sand is composed of small, rounded grains of transparent quartz, colored light buff by a little adhering ochreous material; it contained a few small spangles of mica.

It would be easy, by this simple process of washing, to separate the ochre from the fine sand with which it is naturally mixed. The washed ochre, although not very bright, is of a good color, and could be very well used for a cheap and durable paint for outside work. Calcined in the fire, it becomes of a good Venetian red color.

No. 2104—"*Clay, at least four feet thick, from near Moore's Mill. Base of hill on the north side of the Columbus and Blandville road; one mile southwest of Blandville.*" *Collected by John R. Procter.*

Clay in friable lumps; generally of a very light grey color, nearly white; mottled somewhat with ochreous material. It is quite plastic with water, and calcines of a light salmon color.

Quite refractory before the blow-pipe. Washed several times with water, allowing ten minutes each time for subsidence, it left nearly 48 *per cent. of quite fine white sand*, which was so fine, indeed, that it was somewhat plastic while wet, and adherent when dry.

On comparing the composition of this clay with that of the celebrated German Glass Pot Clay, so extensively imported by our glass manufacturers, a remarkable resemblance is observable. That the comparison may be made by our readers, we copy here the results of two analyses of the German clay, from Geological Reports of Kentucky, Vol. IV, N. S., p. 163, marked H and I, and place them by the side of that of the clay above described, No. 2104, as follows:

COMPOSITION, DRIED AT 212° F.

	No. 2104.	H.	I
Silica, including pure sand	74.460	70.860	73.660
Alumina	18.070	20.900	19.460
Iron peroxide	1.633	1.560	1.560
Lime	.314	.347	.168
Magnesia	.245	.220	.209
Potash	.940	.578	.520
Soda	.021	.112	.046
Water expelled at red heat and loss	4.317	6.800	6.200
Total	100.000	101.377	101.823

If this clay is in sufficient quantity in this locality, it certainly deserves trial in the glass-house for this important use, as the importation of the German clay for glass pots, now considered indispensable, is quite expensive. At all events, this No. 2104 is quite a refractory fire-clay, although it contains more potash than the imported article, which may possibly impair its value in this respect.

Other sandy clays; one from Graves county, No. 2143, and one from Hickman county, No. 2162 of present report, closely resemble this in composition, but containing rather more potash; also deserve trial in this relation.

No. 2105—"*Clay, from the farm of Mr. T. D. Campbell, in South Ballard county.*" *Sent by John R. Procter.*

In a friable lump, as soft as chalk, of a handsome, light purplish-grey color, presenting a somewhat stratified appearance, because of interrupted thin laminæ of lighter material. It shows a few ochreous specks, and appears to be somewhat sandy.

Washed in water, it left fifty-four per cent. of very fine sand of a light lilac color, some more of still finer sand being left in the washings. It is quite plastic, decrepitates strongly when exposed to heat, unless it is thoroughly dry. Calcines hard; of a handsome light purplish-grey color. Before the blow-pipe it proved quite refractory.

COMPOSITION, DRIED AT 212° F.

Silica	67.501
Alumina, &c.	23.051
Iron peroxide	2.109
Lime	.257
Magnesia	.065
Potash	.412
Soda	.020
Combined water, &c., and loss	6.585
Total	100.000

This clay would, no doubt, answer well for many forms of pottery, as well as for fire-bricks. But for the somewhat undue proportion of iron oxide, it might probably serve all purposes of the most refractory clay.

No. 2106—"*Impure sand, from T. D. Campbell, southern part of Ballard county.*"

A dirty, olive-brownish sand, abundantly mixed with ochreous or ferruginous material, mottled with blackish, containing some ochreous sandy concretions.

Digested in chloro-hydric acid, it left nearly ninety-eight per cent. of sand, composed mostly of rounded grains of hyaline quartz, mixed with some very fine sand, and some few rounded pebbles of milky quartz of various sizes. The acid dissolved out of it less than two per cent. of alumina and iron and manganese oxides, with traces of lime, magnesia, &c.

This sand would answer well for the manufacture of the common kinds of glass in extensive use, as well as for mixing with cement and mortar for building purposes, &c.

MINERAL WATERS FROM BALLARD COUNTY.

No. 2107 A—"*Water from the 'Bluff Spring.' On the road from Columbus to Cairo, in the milk-sick region, and supposed by some to cause this sickness.*" *Sent for examination by Hon. S. H. Jenkins.*

The water had deposited a considerable brownish sediment, which did not all dissolve in chloro-hydric acid.

Qualitative analysis showed the presence of some free carbonic acid, much of bi-carbonates of lime and magnesia, some little bi-carbonate of iron, and of chlorine and sulphuric acid in combination.

The water had a slightly alkaline reaction, and the spectroscope showed the presence of a trace of lithium. There is no reason to suppose that this water has anything to do with the causation of milk-sickness.

No. 2107 B—"*Water from the 'Mahon Spring.' Said to be unhealthy, and by some thought to cause milk-sickness.*" *Sent by Hon. S. H. Jenkins.*

Qualitatively examined, it gave similar reactions with the water from the "Bluff Spring," but did not seem to contain as much iron; and there was no brown sediment in the bottle containing it.

A weighed portion of this water, evaporated to dryness, left only 0.36 per thousand of the water of whitish saline residue, dried at 212°. The soluble part of this had an alkaline reaction, and the spectroscope showed the presence in it of soda and lithia.

It seems to be a perfectly wholesome water, although, like the above, somewhat "hard" from the presence of lime and magnesia bi-carbonates. The water A is also slightly chalybeate.

CLARK COUNTY.

No. 2108—"*Water from a bored well, seventy-two feet deep, near Winchester. Bored through limestone and so-called 'soapstone' (or marlite).*" *Brought by Mr. B. F. Vanmeter, and analyzed for him.*

The water was slightly alkaline in reaction, contained no hydrogen sulphide, and had formed no sediment in the bottle in which it was brought to the laboratory.

Evaporated to dryness, 1000 parts of the water left only 0.5912 part of saline matters, dried at 212° F. These were quite alkaline in reaction, and the spectroscope showed the presence in them of soda, lithia, potash, strontia, and a doubtful trace of baryta.

Qualitative analysis detected much chlorine, some carbonic acid, and a little sulphuric acid, in combination with a considerable proportion of lime and magnesia, as well as with the bases above mentioned, but no sensible quantity of iron.

This water is much more free from saline matters and hydrogen sulphide than what is usually obtained by boring to such a depth in this limestone region.

CLINTON COUNTY.

SOILS.

No. 2109—"*Virgin soil from the farm of Lewis Huff, at the north end of the 'Copperas Knob,' at Huff's coal bank; one mile east from the 'Livingston road' and from Mr. Huff's house; about three miles west of south of Long's Gap. Geological position, on the first terrace above the sub-carboniferous limestone, and the second below coal, and on the steep terrace slopes of the coal-bearing sandstone and shales.*" *Collected by Joseph Lesley, jr., July,* 1859.

The dried soil is friable, and of a dark umber-grey color. The coarse sieve separated from it 22.4 per cent. of irregular, slightly-rounded fragments, some pretty large, of ferruginous sandstone or silico-ferruginous concretions. The analysis given below was of the "fine earth" separated from these fragments by the coarse sieve; and the ultimate value of these soils must therefore be discounted by the amount of these

coarse, rocky fragments thus separated. The bolting-cloth removed from the silicious residue (stated as sand and insoluble silicates) a considerable proportion of small grains of partly decomposed concretions or silicates, easily crushed to fine powder, and a few small, rounded quartzose particles.

No. 2110—"*Surface soil from the same field as the preceding. Was cleared in* 1853. *Has been in corn every year, including the present* (1859)." *Collected by Jos. Lesley, jr.*

The dried soil resembles the preceding; is very slightly darker than that. The coarse sieve removed from it 27 per cent. of ferruginous silicious fragments; some large; not rounded.

The bolting-cloth separated from the sand and insoluble silicates only a small proportion of particles of partly-decomposed concretions or silicates, and a very few small, rounded grains of white quartz.

No. 2111—"*Subsoil of the next preceding*," *&c., &c.*

This subsoil is slightly darker colored than the preceding, which it resembles. The coarse sieve removed from it 14.2 per cent. of irregular fragments of ferruginous sandstone, not much rounded, and a few small, rounded quartz pebbles.

All the silicious residue, from digestion in acids, passed through the bolting-cloth, except a small proportion of soft particles of partly-decomposed silicates or concretions, and very few small, rounded quartz grains.

No. 2112—"*Virgin soil from the farm of John Wade, on the head of Indian creek, on the Monticello and Albany road, sixteen and three quarter miles southwest of the former place, and seven miles northeast of the latter; one mile north of Wade's Gap, and at the south foot of 'Short Mountain.' Geological position, sub-carboniferous limestone.*" *Collected by Joseph Lesley, jr.*

This dried soil is of a light brownish-grey color. It is quite friable and light. The coarse sieve separated from it as much as 29.5 per cent. of angular fragments of chert and somewhat rounded particles of ferruginous sandstone. All of its silicious

residue passed through the bolting-cloth except a small proportion of small, rounded grains of white quartz, and a few particles of partly decomposed silicates or concretions.

No. 2113—"*Surface soil from a field across the road from the place of the next preceding. Now* (1859) *in corn; last year in wheat; year before in grass. Was cleared in* 1803, *and for twelve years was set uninterruptedly in corn, and has been cultivated ever since, with not enough manure to speak of.*" *Collected by Joseph Lesley, jr.*

The dried soil is of a light snuff color, but darker colored and more brownish than the next preceding; friable. The coarse sieve removed only 4.4 per cent. of somewhat rounded ferruginous sandstone fragments, with a few small quartzose concretions. All the silicious residue passed through the bolting-cloth, except a small proportion of small, rounded white quartz grains and a few of partly decomposed silicates or concretions.

No. 2114—"*Subsoil of the next preceding,*" *&c., &c.*

This dried subsoil is very much like the soil next preceding, but is of a slightly darker color. It is quite friable. The coarse sieve separated from it 8.2 per cent. of somewhat rounded particles of ferruginous sandstone. All the silicious residue passed through the bolting-cloth, except a small proportion of small rounded grains of white quartz and a few of partly decomposed silicates or concretions.

COMPOSITION OF THESE CLINTON COUNTY SOILS, DRIED AT 212°.F.

	No. 2109.	No. 2110	No. 2111	No. 2112.	No. 2113.	No. 2114.
Organic and volatile matters	6.615	9.275	6.910	3.000	4.320	4.695
Alumina and iron and manganese oxides	5.984	6.687	6.951	2.932	6.129	6.247
Lime carbonate	.405	.620	.480	.080	295	.195
Magnesia	.232	.232	.223	.106	.124	.108
Phosphoric acid (P_2O_5)	.166	.173	.259	.093	.071	.093
Potash extracted by acids	.212	.274	.222	.155	.170	.188
Soda extracted by acids	not est.	not est.	not est.	not est.	not est.	not est.
Water expelled at 380° F.	1.400	1.810	1.665	1.550	1.940	1.500
Sand and insoluble silicates	84.990	81.165	83.365	92.240	86.790	86.790
Total	100.004	100 236	100.075	100.156	99.839	99.816
Hygroscopic moisture	1.585	1.990	1.750	0.900	1.800	1.515
Potash in the insoluble silicates	983	.098	.972	.327	.726	.621
Soda in the insoluble silicates	217	.101	.158	.269	.263	.169
Percentage of gravel	22.400	27.000	14.200	29.500	4.400	8.200
Character of the soil	Virgin soil	Old field.	Subsoil.	Virgin soil	Old field.	Subsoil.

These Clinton county soils are from two different geological horizons; Nos. 2109, 2110, and 2111 being from the coal-measure sandstones and shales, while Nos. 2112, 2113, and 2114 are based on the sub-carboniferous limestone. Strange as it may appear, these coal-measure soils seem to be the richest in essential ingredients. Were it not for the considerable proportion of ferruginous sandstone fragments or gravel contained in these, they might be classed amongst our most productive soils, as their "fine earth," the analyses of which are given above, contains a full average proportion of potash, phosphoric acid, lime, magnesia, organic matters, &c.

The soils Nos. 2112, 2113, and 2114 are somewhat deficient in phosphoric acid, and it is remarkable that No. 1112, the virgin soil of the set, is much poorer than the soil of the old field, No. 2113, which has been in cultivation for fifty-six years, and that it is quite deficient in lime carbonate as compared with that. But this fact, as well as its much larger proportion of gravel, of a different kind from that of the other, and its lighter color, as compared with the soil of the old field and the subsoil, indicate that this and these other soils were derived from different geological sources.

CRITTENDEN COUNTY.

SOILS.

No. 2115—"*Virgin soil; half an inch below the surface. Soil two to four inches deep. Ridge land a mile and a half east of the Sulphur Springs, Crittenden county. Farm of S. C. B. McMican. Soil is derived from sandstone. Supports a growth of black, white, post, Spanish, and some black-jack oaks, poplar, hickory, elm, ash, black gum, dogwood, and some sassafras and papaw.*" *Collected by C. J. Norwood.*

A light soil, of a grey-buff or drab color. It all passed through the coarse sieve except vegetable débris.

All the sand and insoluble silicates left after digestion in the acid passed through bolting-cloth, except a small proportion of soft grains of partly-decomposed concretions, and a very few minute, rounded white quartz grains.

No. 2116—"*Subsoil of the next preceding*," *&c., &c.*

The subsoil is of a brownish-yellow ochre color, in quite firm clods. It all passed through the coarse sieve except some vegetable débris. The bolting-cloth separated from the sand and insoluble silicates more than half its weight of small, rounded particles of partly-decomposed concretions, easily crushed under the finger, and a very few small, rounded grains of white quartz.

No. 2117—"*Surface soil on ridge land; from a field in cultivation for eight years; 1st in tobacco, 2d and 3d in corn, 4th in wheat, 5th, 6th, 7th, and 8th in corn. No fertilizers used. The soil is from three to six inches deep, derived from sandstone. Sample taken one inch from the surface. Same farm as the two preceding.*" *Collected by C. J. Norwood.*

All passed through the coarse sieve except vegetable débris and a few small ferruginous concretions. The bolting-cloth separated from the silicious residue only a small proportion of particles of partly-decomposed concretions, and a very few minute, rounded grains of white quartz.

No. 2118—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil is of a greyish-yellow ochre color; lighter than that of the virgin soil. It is in somewhat firm clods, but it all passed through the coarse sieve.

The bolting-cloth removed from the sand and insoluble silicates about half their weight of small soft particles of partly-decomposed concretions or silicates, and only some three or four small, rounded grains of white or hyaline quartz.

COMPOSITION OF THESE CRITTENDEN COUNTY SOILS, DRIED AT 212° F.

	No. 2115.	No. 2116.	No. 2117.	No. 2118.
Organic and volatile matters	2.225	2.950	3.260	2.885
Alumina and iron and manganese oxides	3.629	8.718	4.868	8.173
Lime carbonate	.160	.145	.270	.170
Magnesia	.304	.350	.214	.703
Phosphoric acid (P_2O_5)	.086	.092	.067	.102
Potash extracted by acids	.090	.309	.171	.122
Soda extracted by acids	n. e.	.118	n. e.	n. e.
Water expelled at 380° F.	.875	.925	1.225	.950
Sand and insoluble silicates	92.705	86.665	89.440	86.490
Total	100.074	100.272	99.515	99.595
Hygroscopic moisture	0.890	0.925	1.565	2.000
Potash in the insoluble silicates	1.876	2.023	1.707	1.755
Soda in the insoluble silicates	.896	.750	.694	.588
Character of the soil	Virgin soil	Subsoil.	Old field.	Subsoil.

These soils, although derived from sandstone, and containing a considerable proportion of sand and insoluble silicates; in No. 2115 as much as 92.705 per cent.; may yet be preserved in a fertile condition for an unlimited time by judicious management and the use of appropriate fertilizers. What we denominate "sand," however, in the statement of the composition of these and other soils, is in such a state of fine division as to pass freely through a sieve having 1600 meshes to the centimetre square; and while it renders the soil light and readily permeable by water and the gases, is yet so finely divided as to present in some degree the plastic properties of clay, as well as the property of attracting and holding, with surface attraction, the gases and the fertilizing materials with which it is brought in contact.

The influence of fine division of the soil has been recognized by experience, so that the German and French agricultural chemists mainly disregard the pebbles and coarse sand which enter into the composition of a soil, and estimate its fertility by the proportion and composition of the "fine earth" which it contains. This, indeed, has been the method pursued in this work for the Kentucky Geological Survey.

The soils above described contain quite a sufficient quantity of lime and magnesia, and, generally, a good proportion of potash; the ridge soil, No. 2115, showing, however, a slight deficiency in this respect; but as the phosphoric acid appears to be in rather small amount in them, the use of phosphatic fertilizers would doubtless be profitable; associated, as they always should be, with some nitrogenous material. Their fertility might, no doubt, also be improved by increasing their proportion of organic matters, by the use of barn-yard manure, or plowing under green crops, &c. Deep plowing might also be advantageous, as the subsoil is rather richer than the surface.

FAYETTE COUNTY.

No. 2119—"*Salt sulphur water from a bored well seventy-one feet two inches deep; six feet and a half of which was through soil, subsoil, and under-clay; the rest through the hard limestone rock of the Lower Silurian formation. On the farm of Mr. John C. Innis, on the Russell road, about seven miles north of Lexington.*" *Brought by Mr. Innis.*

The water contained hydrogen sulphide in notable quantity, and carbonic acid. Evaporated to dryness, it left 2.2 parts of *saline matters*, dried at 212°, to the thousand of the water, which gave a slightly alkaline reaction with reddened litmus.

By qualitative analysis the saline matters of this water were found to contain much sodium chloride (common salt); also much lime in combination, some magnesia, and a small quantity of sulphates, &c.; in short, the usual saline constituents of the rocks of this region, which lie below the surface drainage; found in the waters of almost all the deep-bored wells, and brought out in the waters of such deep-seated springs as those of the lower Blue Licks, &c., and which are derived originally, no doubt, from the primeval ocean under which the rock strata were formed.

No. 2120—"*Marly clay, occurring in a bed described as being a foot and a half thick, in the Lower Silurian limestone strata on Elk Lick, between the Kentucky river and the Lexington and Richmond Turnpike, just above the so-called 'petrified falls' of Elk Lick.*" *Collected by Waldemar Mentelle.*

A whitish clay, mottled with brownish ochreous. Quite plastic. Effervesces with chlorohydric acid. At a moderate red heat it calcines (or "burns") of a handsome flesh color, which property might commend it for use for terra-cotta, if in sufficient abundance. Before the blow-pipe it readily fuses into a whitish slag.

COMPOSITION, DRIED AT 212° F.

Silica	53.780
Alumina	23.260
Iron peroxide	1.300
Lime	4.866
Magnesia	.568
Phosphoric acid (P_2O_5)	.191
Potash	7.612
Soda	.550
Combined water, carbonic acid, and loss	7.873
Total	100.000

The considerable proportions of lime, magnesia, potash, and soda account for the fusibility of this clay at a high temperature. It resembles the usual marly clay layers of the Lower Silurian formation, and contains quite a large proportion of combined potash.

FRANKLIN COUNTY.

No. 2121—"*Limestone, supposed to be hydraulic or water lime. Kentucky river bluffs; north side; at the end of Dam No. 4. Bed three to ten feet thick. Trenton Group.*" *Collected by John R. Procter.*

A pretty compact or fine granular rock; not adhering to the tongue. Some layers laminated and slightly adherent. Generally of a dull, dark brownish, olive-grey color. Contains a few indistinct, small encrinital joints in the compact portion.

COMPOSITION, DRIED AT 212° F.

Lime carbonate	70.360	= Lime, 39.401
Magnesia carbonate	6.784	= Magnesia, 3.236
Alumina	5.458	
Iron peroxide	1.342	
Phosphoric acid	not est.	
Potash	1.118	
Soda	.281	
Silica	14.020	
Total	99.363	

Some of the rock was calcined at a moderate red heat in the powdered state, for about one hour. It still effervesced a little with acids. Mixed with water into a paste, both with sand added and without, and partly immersed in water, both samples became only moderately hard. A portion was then calcined at a white heat, so that it became partly sintered, but the powdered product did not harden as well even as that which had been more moderately heated. It seems, therefore, that this does not promise well as a water cement when calcined without admixture. Comparing it with the celebrated water cement rock prepared near the Falls of the Ohio, near Louisville (see table at end of this report), we find that, while this Kentucky river rock contains a larger proportion of potash than that, it is relatively deficient in silica as compared with its lime. Indeed, we found that when calcined it slacked hot with water, and showed other properties of "fat" lime.

No. 2122—*"Water from the Kentucky river, collected just below the bridge at Frankfort," by John R. Procter. Brought to the Laboratory in a new, well-glazed stone-ware jug, stopped with a cork.*

The water was slightly turbid, and deposited a light brownish-red sediment on standing, which contained very fine sand and red oxide of iron. It is slightly alkaline in its reaction, and left, on evaporation to dryness, only about 0.13 to the thousand parts of the water of solid saline residue, dried at 212 F. This saline residue was very slightly colored with brownish organic matter, and consisted mainly of carbonates

of lime and magnesia, which were held in solution in the water by carbonic acid; some chlorides, no doubt, of potassium, sodium, &c.; a small amount of sulphate of some of the bases mentioned; a trace of alumina and iron and manganese oxides, and a little dissolved silica.

Were it not for the trace of reddish organic matter in this water, it would be, after its sediment had been deposited by allowing it to stand at rest or removed by filtration, a remarkably good natural water; and it is probable that it would be found more free from saline and other impurities if collected above the limits of the town. It would be interesting and useful more fully to examine the water of this river, as well as of our other rivers, at different seasons of the year, especially because the use of these waters may greatly affect the health of the public; and the successful practice of many of the industrial arts depends on pure water.

FULTON COUNTY.

SOILS.

No. 2123—"*Top soil, from Mississippi bottom land, three miles southwest from Hickman, Fulton county. Principal growth. white oak, hickory, gum, and beech.*" *Collected by John R. Procter.*

The dried soil is in pretty firm clods, of a light yellowish-umber color. The coarse sieve* removed from it only a very small portion of vegetable débris. All of its silicious residue, left after digestion in acids, passed through the fine† sieve, except a small proportion of small particles of partly decomposed concretions, and only one or two small quartz grains.

No. 2124—"*Soil from the surface of a field twelve years in corn without manure. Mississippi bottom land, about two miles south of Hickman. Yield this season* (1878) *over fifty bushels of corn per acre.*" *Collected by John R. Procter.*

Dried soil in friable clods, of an umber color.

* The coarse sieve has about sixty-four meshes to the centimeter square.

† The fine sieve has about 1600 meshes to the centimeter square.

No. 2125—"*Virgin soil, from the land of Dr. G. W. Pascal, half a mile north of Fulton, Fulton county.*" *Collected by John R. Procter.*

The dried soil is in quite friable clods, of a light grey-brown color.

No. 2126—"*Surface soil, from an old field forty years in cultivation. Farm of Dr. Pascal, half a mile from Fulton. Sample taken three to twelve inches below the surface.*" *Collected by John R. Procter.*

The dried soil of a light yellowish grey-brown color. Clods friable.

No. 2127—"*Subsoil of the next preceding. Taken from thirteen to twenty inches below the surface.*" *Collected by John R. Procter.*

The dried subsoil is of a brownish-buff color. The clods are more firm than those of the preceding soil. The silicious residue of this, as well as of the other soils of this locality, described above, all passed through the bolting-cloth, except a very small proportion of small grains of partly-decomposed concretions, and of quartz. The soils all passed through the coarse sieve, with a small residue in some of vegetable débris and small ferruginous concretions.

No. 2128—"*Virgin soil. Farm of Capt. Henry Tyler, three miles southeast from Hickman, Fulton county. Growth: mostly poplar, maple, white and Spanish oaks, and some walnut.*" *Collected by John R. Procter.*

The dried soil is of a brownish-grey color. The clods are friable, and mottled with lighter grey and light ferruginous tints. The coarse sieve separated from it but a small proportion of partly rounded ferruginous particles. Its silicious residue all passed through the fine sieve except a very small proportion of small, rounded particles of partly-decomposed concretions, with no quartz particles.

No. 2129—"*Subsoil of the next preceding, &c., &c.; taken twenty-four inches below the surface.*" *Collected by John R. Procter.*

The dried subsoil is of a grey-buff color. The clods are quite firm, mottled with darker and yellowish tints. The bolting-cloth removed from the silicious residue a considerable proportion of small, soft grains of partly-decomposed concretions, but no quartz sand.

No. 2130—"*Top soil, first ten inches from surface; from an old field near the location of the next preceding soil, on Capt. Henry Tyler's farm, &c., &c. The land is in corn, as it was last year. The yield this year* (1877) *is sixty-five bushels per acre. There is a good deal of soil similar to this on the uplands bordering on the Mississippi river. Noticed similar soil in the western part of Ballard county.*" *Collected by John R. Procter.*

The dried soil is of a dark mouse color. The clods are friable. The coarse sieve removed from it only a little vegetable débris.

The fine sieve separated from the silicious residue, left after digestion in acids, a notable proportion of small, soft, rounded grains of partly-decomposed concretions, and one or two quartz grains.

No. 2131—"*Subsoil of the next preceding; taken carefully from fifteen to twenty-four inches below the surface. The bulk of the sample is from twenty-four inches below the surface.*" *Collected by John R. Procter.*

The dried subsoil is in very firm clods, of a dark mouse color. The bolting-cloth separated from the silicious residue a very large proportion, about one half, of small particles of somewhat rounded, partly-decomposed concretions.

No. 2132—"*Virgin soil; upland. On Capt. Henry Tyler's farm. Timber, proportion in the order named: black walnut, white oak, sugar maple, and red oak.*" *Collected by John R. Procter.*

Dried soil in friable clods, of a dirty drab color. The coarse sieve separated only a small portion of vegetable débris. All the silicious residue, from digestion in acids, passed through the bolting-cloth, except a single small quartz grain.

No. 2133—"*Subsoil of the next preceding soil, from Capt. Tyler's farm; taken twelve to twenty-four inches below the surface.*" *Collected by John R. Procter.*

Dried subsoil in firm clods, of a dark buff color. All passed through the coarse sieve. The silicious residue all passed through the bolting-cloth, except a small proportion of soft granules of partly-decomposed concretions. It contained no quartz grains.

COMPOSITION OF THESE FULTON COUNTY SOILS, DRIED AT 212° F.

	No. 2123	No. 2124	No. 2125	No. 2126	No. 2127	No. 2128	No. 2129	No. 2130	No. 2131	No. 2132	No. 2133
Organic and volatile matters	9.305	4.725	3.075	2.300	2.535	3.090	2.285	8.375	4.140	2.860	2.165
Alumina and iron and manganese oxides	10.437	5.127	5.335	4.974	8.690	3.825	7.700	6.860	10.560	3.560	6.550
Lime carbonate	1.385	1.045	.360	.190	.195	.395	.145	1.395	.795	.345	.110
Magnesia	.461	.234	.175	.162	.331	.214	.268	.598	.169	.142	.232
Phosphoric acid	.198	.198	.055	.156	.125	.125	.115	.125	.115	.125	.140
Potash extracted by acids	.142	.321	.179	.290	.141	.066	.186	.332	.208	.074	.275
Soda extracted by acids	not est	.419	not est.	.124	.098	not est.	.142	.073	.317	.182	.050
Water expelled at 380° F.	3.110	1.150	1.025	.775	.900	1.050	.840	2.650	1.501	.975	.650
Sand and insoluble silicates	74.840	87.145	89.945	91.745	86.895	91.125	87.795	79.340	82.395	91.740	89.670
Total	99.878	100.364	100.149	100.716	99.910	99.890	99.476	99.748	100.200	100.003	99.842
Hygroscopic moisture	4.100	2.350	1.685	1.400	2.585	1.335	2.610	3.585	3.975	1.000	1.725
Potash in the insoluble silicates	1.889	1.814	1.767	1.664	1.892	1.784	1.675	1.865	1.873	1.969	1.935
Soda in the insoluble silicates	.607	.858	.828	.749	.715	1.208	.893	1.030	.841	.892	.991
Character of the soil	Top soil.	Cultivated soil.	Virgin soil.	Old field	Subsoil.	Virgin soil.	Subsoil.	Old field	Subsoil.	Virgin soil.	Subsoil.

There is a considerable resemblance between the soils Nos. 2123 and 2130. They both seem to be soils of more than average fertility, containing, as they do, large proportions of organic and volatile matters, and, consequently, of hygroscopic moisture; also more than the usual quantities of alumina, &c., of lime, magnesia, phosphoric acid, and the alkalies, and leaving but a moderate quantity of silicious residue when digested in acids. If well drained, these soils will doubtless be of durable fertility.

The soils Nos. 2126, 2128, and 2131 contain more of the silicious material than the above-mentioned, and Nos. 2128 and 2132 seem to be somewhat deficient in immediately available potash; but they contain an average proportion of lime, magnesia, phosphoric acid, and generally a large amount of reserve alkalies in their silicious residues. Moreover, being of a fine texture, their small proportions of alumina, &c., will not be as great a drawback to their productiveness as might be supposed. The other soils take an intermediate position between these two groups mentioned. No. 2125 is to be distinguished by its apparent deficiency of phosphoric acid, which, however, can be easily remedied by the judicious use of phosphatic fertilizers. Organic and volatile matters seem to be in small proportion in Nos. 2126 and 2132. The subsoil, No. 2127, also shows but a small proportion; but this is a common character of subsoils.

Although these soils vary considerably in their natural fertility and probable durability, there is no reason why they all may not be kept permanently productive with judicious management and the timely use of manures.

SILICIOUS RESIDUE OF SOILS.

Desirous of ascertaining whether any notable quantity of phosphoric acid, &c., had resisted the action of the acids used in the ordinary analyses of soils, in addition to the potash and soda, the presence and proportions of which have been determined in so many of these silicious residues, some of them, after thorough digestion in nitric acid, with the addition of a little hydrochloric acid in the process for the determination

and removal of the soluble phosphoric acid, were analyzed by preliminary fusion with the alkaline carbonates and the approved processes, with the following results, viz:

COMPOSITION CALCULATED INTO 100 PARTS OF THE SILICIOUS RESIDUES, DRIED AT 212° F.

	No. 2123.	No. 2128.	No. 2132.	Average composition of 8 of these residues.
Silica	83.931	88.298	90.236	88.460
Alumina, with trace of iron	12.043	6.075	6.689	6.789
Lime	.791	.744	.600	not estimated.
Magnesia	.080	.043	.044	.569
Phosphoric acid	.077	.186	.039	1.151
Potash	2.524	1.947	2.147	3.295
Soda	.808	1.569	1.167	
Total	100.254	98.862	100.922	100.264

It is interesting to note, in these silicates of the soil which have resisted the decomposing action of nitric and hydrochloric acids for a space of seven to ten days in the sand bath, so much of some of the essential elements of plants and animals usually to be found only in small proportion in soils. These, although in this present insoluble state, are, as in all other silicates, subject to gradual decomposition under the ordinary natural agencies, by weathering, as it is termed; and hence may be considered as a reserve store of plant-food, which may prolong the duration of the productiveness of soils. (See, under Nelson county, another of these analyses.)

CLAYS OF FULTON COUNTY.

No. 2134—"*Indurated clay from the bluff at Hickman; forty-five feet above low water.*" *Collected by John R. Procter.*

Clay generally of a grey color, with some light ferruginous stains in the fissures. Lumps quite firm when dry, breaking with an irregular fracture. Quite plastic with water when powdered. It calcines of a light buff color, and fuses before the blow-pipe into a grey slag.

No. 2135—"*Clay from the bluffs at Hickman; ninety-five feet above low water. Is it a fire-clay?*" *Collected by John R. Procter.*

In pretty firm lumps, generally of a light grey tint, but is considerably mottled with light brownish ochreous material.

Quite plastic with water. Calcines of a reddish buff color. It is refractory before the blow-pipe; but sintered somewhat.

No. 2136—"*Clay from Hickman bluff; upper part of the town. First clay beneath the gravel bed; about four feet thick. Tertiary formation.*" *Collected by John R. Procter.*

The dried clay is a light grey tint, colored buff and ferruginous in parts by infiltration. It is moderately plastic, and did not calcine very hard, acquiring a handsome light brick color. Refractory before the blow-pipe.

No. 2137—"*Clay from Hickman bluff, same bed as that of the next preceding, but a quarter of a mile further up the bluff; three to four feet thick.*" *Collected by John R. Procter.*

This clay is somewhat lighter colored than the preceding, and shows very little ferruginous infiltration. It is quite plastic. Burns hard, and of a light greyish-buff tint. Before the blow-pipe it fuses with great difficulty.

No. 2138—"*Clay from Hickman bluff, upper part of the town, about ten feet below the base of the gravel. Bed about four feet thick, with about four feet of potter's clay resting on it. It is probably the same as the clay collected from Hamby Hill. Tertiary.*" *Collected by John R. Procter.*

The dried clay is in pretty hard lumps, of a light grey color, infiltrated somewhat with ochreous material in striæ. Quite plastic. Calcined of a light brick color. Quite refractory before the blow-pipe.

No. 2139—"*Clay above the next preceding; about four feet thick.*" *Collected by John R. Procter.*

The dried clay is in moderately hard lumps, generally of a light lilac-grey, colored on the exterior ochreous and ferruginous. It is quite plastic; burns hard, of a light grey-buff tint. Before the blow-pipe it fuses with difficulty.

No. 2140—"*Clay from Hickman bluffs, upper part of the town; bed about five feet thick, below the next preceding. Tertiary.*" *Collected by John R. Procter.*

Dried clay, of a light lilac-grey color; in moderately hard lumps; stained with ochreous on the exterior. It is quite

plastic. Burns quite hard, and of light brownish-buff tint. Quite refractory before the blow-pipe.

No. 2141—"*Clay; bed about twenty feet thick, or more; above the railroad track. Upper part of the town of Hickman. Tertiary.*" *Collected by John R. Procter.*

Dried clay, in moderately hard lumps; of a pretty uniform light olive-grey color. It calcines quite hard, and of a brownish-buff color. Quite refractory before the blow-pipe.

No. 2142—"'*Loess or Bluff*' *from Hickman bluff. Quaternary.*" *Collected by John R. Procter.*

In very friable lumps, of a light grey-buff color. Contains remains of land and fresh water shells. It is somewhat plastic; not very coherent when burnt; acquiring a very light brick color; before the blow-pipe fuses into a light grey slag.

COMPOSITION OF THESE HICKMAN BLUFF CLAYS, FULTON COUNTY, DRIED AT 212° F.

	No. 2134	No. 2135	No. 2136	No. 2137	No. 2138	No. 2139	No. 2140	No. 2141	No. 2142
Silica	64.800	76.860	83 380	71.340	83.500	71.080	74.100	77.960	68.860
Alumina	21.070	14.600	9.800	17.190	9.940	19.050	16.460	13.970	12.980
Iron oxide	5.270	3.020	2.120	2.770	2.500	2.810	2.700	2.390	2.240
Lime	1.400	.425	.963	1.612	.358	.627	.358	.134	9.587
Magnesia	.050	.308	.187	.209	.173	.401	.187	.163	1.182
Potash	.646	.736	.617	.925	.539	.578	.559	.797	1.773
Soda	.202	257	.118	.232	.109	.225	.135	.124	1.278
Combined water and loss	6.562	3.794	2.815	5.722	2.881	5.227	5.501	4.462	2.100
Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

It is evident that the Tertiary bluffs, from which these clays were collected, offer some valuable materials to the industrial arts. Some of these are quite refractory in the fire, especially Nos. 2136, 2138, 2140, and 2141, and would probably make good fire-bricks, &c.; others of them could be employed for terra-cotta work and other forms of pottery; while some of these abundant deposits might, no doubt, be used with advantage, in mixture with the more calcareous soft material found in some of these beds, in the manufacture of hydraulic cement of the character of the celebrated Portland cement. The loess layer material might be made useful as top-dressing to heavy clay soil.

GRAVES COUNTY.

No. 2143—"*Clay, from Wm. P. Arnett's land, on Panther creek. The bed shows eight feet above the creek.*" *Collected by John R. Procter.*

Clay of a uniform grey color, apparently quite sandy. Washed with water, it left about sixty-three per cent. of fine sand of an umber-grey color, containing small spangles of mica and some coarser grains of transparent quartz. It is quite plastic, and burns of a light salmon color; does not become very hard unless exposed to a very high temperature. It is refractory before the blow-pipe.

COMPOSITION, DRIED AT 212° F.

Silica	75.550	Of which 63 per cent. of fine sand.
Alumina	16.751	
Iron peroxide	1.198	
Lime	a trace.	
Magnesia	.144	
Potash	1.094	
Soda	.216	
Combined water and loss	5.047	
Total	100.000	

This clay resembles that from Ballard county, No. 2104, which is compared with the German glass-pot clay; but both this and that contain more potash than the foreign material, which may possibly cause it to be less available to the glass-maker. It could no doubt be made useful for many purposes, as a fire-clay as well as for various pottery applications.

No. 2144—BITUMINOUS SHALE, *labeled* "*Brown coal, from Mr. Wm. Arnett's land, on Panther creek, six miles east of Mayfield, on the Columbus and Hopkinsville road. Bed showing about three feet above the creek, said to be several feet below that level.*" *Collected by John R. Procter.*

A soft laminated, bituminous shale or clay; of a dark chocolate color, showing numerous impressions of vegetable leaves.

COMPOSITION, DRIED AT 212° F.

Hygroscopic moisture	4.13	Total volatile matters = 20.35
Volatile combustible matters	16.22	
Fixed carbon in the coke	10.25	Total pulverulent coke = 79.65
Light ash, nearly white	69.40	
	100.00	100.00

The ash was found to contain a considerable proportion of alumina, some little lime and magnesia, as well as a trace of phosphoric acid. As this material only contains a little more than thirty-six per cent. of combustible matters, it could scarcely be made available as a fuel. Possibly it may find use as a cheap pigment.

GREENUP COUNTY.

COALS.

No. 2145—"*Coal* (*No.* 3). *Splint coal sampled from the stock pile of the Fulton Coal Company.*" *By John R. Procter.*

The coal breaks into irregular laminæ, which have some fibrous coal between them, and some fine, granular pyrites in parts. The fibrous coal shows the shape of portions of reed-like leaves in some of the laminæ. Generally the coal presents a glossy, pitch-like appearance.

No. 2146—"*Coal* (*No.* 4). *Cannel coal from Indian Run, Greenup county. Sampled from the stock pile of the Fulton Coal Company.*" *By John R. Procter.*

A very tough cannel coal; imperfectly and irregularly laminated, with no fibrous coal between the laminæ, and very little appearance of granular pyrites. It is generally of a dull black color, but some portions have an ebony-like gloss.

No. 2147—"*Coal* (*No.* 4). *Cannel coal from Chinn's Branch, three miles above Greenup. Sampled from the stock pile of the Fulton Coal Company.*" *By John R. Procter.*

This resembles the next preceding, but is not quite so much laminated; some portions give a large conchoidal fracture. It shows very little fibrous coal or granular pyrites.

No. 2148—"*Coal No.* 7 (*Coalton*); *from the Fulton Company tract. Sent for analysis by James A. Johnson. Average sample of a barge load.*"

A pure-looking, bright, pitch like coal, quite firm, with much handsome iridescence on some of the surfaces of its cuboid

blocks. It does not break into regular laminæ, although it shows irregular lamination, with very little fibrous coal between, and no visible granular pyrites. Has some bright pyritous scales in some of the joints.

COMPOSITION OF THESE GREENUP COUNTY COALS, DRIED AT 212° F.

	No. 2145	No. 2146	No. 2147	No. 2148
Specific gravity	1.319	1.286	1.331	1.324
Hygroscopic moisture	5.00	2 00	4.80	6.00
Volatile combustible matters	39.00	47.36	36.90	33.48
Coke	56.00	50.64	58.30	60.52
Total	100.00	100.00	100.00	100.00
Total volatile matters	44.00	49.36	41.70	39.48
Fixed carbon in the coke	49.88	38.24	51.20	56.14
Ash	6.12	12.40	7.10	4.38
Total	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Slightly coherent	Dense.	Dense.
Color of the ash	Lilac-grey	Grey-buff.	Lilac-grey	Lilac-grey.
Percentage of sulphur	1.986	1.554	3.977	2.330

All of these are valuable coals, more especially Nos. 2145 and 2148, because of their small proportions of ash and sulphur. No. 2147 is nearly as good, but the sample analyzed contained more than the average proportion of sulphur. It is probable, however, that this excess of sulphur was accidental in the sample. The cannel coal, No. 2146, which would burn with much flame, would answer well under the steam-boiler or in the fire-place or cooking-stove.

HARRISON COUNTY.

No. 2149—"*Iron ore; from Thomas Hinkston's land.*" *Collected by John R. Procter.*

Generally in conglomeratic lumps, composed of dark colored, somewhat friable, limonite concretions, with some soft reddish ochreous material interspersed.

COMPOSITION, DRIED AT 212° F.

Iron oxide	21.200 =	14.84 per cent. of *iron.*
Alumina and phosphoric acid	12.870	
Lime carbonate	1.290	
Magnesia carbonate	6.621	
Silicious residue	49.690	
Water, &c., and loss	8.329	
Total	100.000	

It contains too little iron for use as an iron ore.

HENDERSON COUNTY.

SOILS.

No. 2150—"*Virgin soil; woodland pasture; bottom land. Farm of W. Thompson, five miles from Henderson Station, on the L. & S. E. Railroad. Said to be very fertile.*" *Collected by C. W. Beckham.*

The general color of this dried soil is dark drab. It contains some moderately firm clods, which, when broken, show a mottling of light ferruginous and bluish-grey tints.

It all passed through the coarse sieve, except some vegetable débris and a few small ferruginous concretions.

The bolting-cloth separated from the silicious residue, left after digestion in acids, a considerable proportion of small grains, the skeletons of decomposed concretions, with a small quantity of small, rounded white quartz grains.

No. 2151—"*Surface soil from a field fifteen years in cultivation in corn, tobacco, and hay. Same locality as the preceding.*" *Collected by C. W. Beckham.*

The dried soil is of a lighter drab color than the preceding, and the clods are not quite so firm. It all passed through the coarse sieve except vegetable débris and a few ferruginous concretions. Its silicious residue, from digestion in acids, all passed through the bolting-cloth, except a small quantity of small, soft particles of partly-decomposed concretions and a very few small, rounded quartz grains.

No. 2152—"*Subsoil of the next preceding,*" *&c., &c.*

The dried subsoil is in very firm clods, which are of a dark, brownish-drab color on the exterior surface, and mottled with brownish-ochreous and bluish-grey in the interior.

It all passed through the coarse sieve. The bolting-cloth separated from its silicious residue a very large proportion —more than one half of the whole—of small particles, the silicious skeletons of partly-decomposed concretions, which were easily crushed by the finger on paper, after which they passed through the bolting-cloth, leaving only a few small, rounded grains of quartz.

No. 2153—"*Surface soil from an old field twenty-five or thirty years in cultivation; said to be worn out. From the farm of J. D. Robsard, twelve miles from Henderson, on the St. L. & S. E. Railroad.*" *Collected by C. W. Beckham.*

The dried soil is in pretty firm clods, of a dirty brownish-buff color. It all passed through the coarse sieve. The bolting-cloth separated a considerable proportion of small, soft, rounded particles of partly-decomposed concretions from its silicious residue, as well as one or two small, rounded grains of quartz.

No. 2154—"*Subsoil of the next preceding,*" *&c., &c.*

The dried subsoil is in firmer clods than the preceding soil. It is of rather a handsome, warm, brownish-ochre color.

It all passed through the coarse sieve. The bolting-cloth separated from its silicious residue a larger proportion of small, soft grains of partly-decomposed concretions than from that of the preceding soil; but no quartz grains.

No. 2155—"*Virgin soil from woods pasture adjoining the field from which the next preceding two soils were taken. Farm of Mr. Kluté, near Henderson. Quaternary formation.*" *Collected by C. W. Beckham.*

This dried soil is quite friable and light, of a brownish ash-grey color. It all passed through the coarse sieve, except vegetable débris and a small quantity of shot iron ore. The bolting-cloth separated from its silicious residue only a very small proportion of particles of partly-decomposed concretions, and only two or three very small, rounded quartz grains.

No. 2156—"*Surface soil; in cultivation about thirty years; principally in corn, oats, clover, and tobacco. Same locality as the next preceding.*" *Collected by C. W. Beckham.*

The dried soil, also light and friable, is of a somewhat darker color than the preceding. It all passed through the coarse sieve, except a small quantity of shot iron ore and of vegetable débris. The bolting-cloth separated from its silicious residue only a small proportion of particles of partly-decomposed concretions, and a very few small, rounded quartz grains.

No. 2157—"*Subsoil of the next preceding, &c., &c. Used for making bricks.*" *Collected by C. W. Beckham.*

The dried subsoil is of a handsome brownish-yellow ochre color. The clods are very firm. The bolting-cloth separated from its silicious residue a large proportion of small, soft particles of partly-decomposed concretions, and no quartz grains.

No. 2158—"*Virgin soil from woods pasture. Farm of S. H. Busbey, ten miles from Henderson, on the St. L. & S. E. Railroad. Quaternary formation.*" *Collected by C. W. Beckham.*

Dried soil of a brownish ash-grey color. Light and friable. It all passed through the coarse sieve, except a small quantity of shot iron ore and vegetable débris. The silicious residue from digestion in acids all passed through the bolting-cloth, except two or three small particles of partly-decomposed concretions and two or three small quartz grains.

No. 2159—"*Surface soil from a field twenty-five years in cultivation, adjoining the location of the next preceding. Tobacco the only crop.*" *Collected by C. W. Beckham.*

The dried soil is light and friable; its color is slightly more yellowish or light-brownish than that of the preceding. It all passed through the coarse sieve, except vegetable débris and

a very small quantity of shot iron ore. Its silicious residue all passed through the bolting-cloth, except a very small proportion of small grains of partly-decomposed concretions and two or three small quartz grains.

No. 2160—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil is of a handsome brownish-yellow ochre color. The clods are quite firm. It all passed through the coarse sieve. The bolting-cloth separated from its silicious residue, left from digestion of the soil in acids, a large proportion of small, soft particles of partly-decomposed concretions, and only two or three very small quartz grains.

COMPOSITION OF THESE HENDERSON COUNTY SOILS, DRIED AT 212° F.

	No. 2150	No. 2151	No. 2152	No. 2153	No. 2154	No. 2155	No. 2156	No. 2157	No. 2158	No. 2159	No. 2160
Organic and volatile matters	4.525	3.150	2.780	2.125	2.900	3.465	3.015	3.290	3.835	2.785	3.350
Alumina and iron and manganese oxides	5.004	3.968	5.879	5.979	10.047	3.113	4.048	9.589	3.364	4.129	9.644
Lime carbonate	.570	.385	.520	.195	.130	.150	.195	.950	.220	.220	.195
Magnesia	.317	.241	.304	.245	.304	.166	.196	.342	.175	.309	.195
Phosphoric acid	.131	.102	.061	.061	.093	.077	.067	.061	.061	.061	.121
Potash extracted by acids	.196	.238	.142	.236	1.097	.363	.550	.429	.371	.382	.357
Soda extracted by acids	.112	.143	not est.	not est.	not est.	.165	not est.	.185	not est.	.123	.109
Water expelled at 380° F.	1.225	.865	.735	.420	.550	.600	.600	.580	.715	.565	.675
Sand and insoluble silicates	87.990	91.315	89.215	90.725	85.365	92.290	91.625	85.040	91.665	91.840	85.890
Total	100.070	100.407	99.636	99.986	100.486	100.359	100.306	00.466	100.406	100.414	100.536
Hygroscopic moisture	1.815	1.200	1.900	1.350	2.575	1.175	1.325	1.850	1.150	1.025	2.100
Potash in the insoluble silicates	1.654	1.619	2.036	1.672	1.755	1.121	1.127	1.278	1.274	1.457	1.573
Soda in the insoluble silicates	.775	.815	.570	.763	.608	.742	.714	.819	.846	.704	.611
Character of the soil	Virgin soil.	Old field	Subsoil.	Old field	Subsoil	Virgin soil.	Old field	Subsoil.	Virgin soil.	Old field	Subsoil.

Although some of these soils contain more than the average proportion of sand and insoluble silicates, and a corresponding small proportion of alumina, &c., these are in such a state of fine division, being fine enough generally to pass through the fine sieve with 1600 meshes to the centimeter square, that this circumstance does not lessen their productiveness as much as might be supposed, while it gives them great permeability. Organic and volatile matters are also in small proportion in them, except in No. 2050, which has an average quantity; but this deficiency can be supplied by the use of barn-yard manure or by plowing under clover or other green crops. They all have more than the average of available potash, which, as well as their light and friable texture, no doubt adapts them to tobacco culture. No. 2154 has much more than the average proportion of this alkali. Their greatest apparent deficiency is of phosphoric acid, which, in Nos. 2152 and 2153 to 2159, inclusive, falls below the average normal proportion in good soils. This defect, however, may find an easy remedy in the application of phosphatic fertilizers, especially bone-dust or superphosphate, &c. The statement that soil No. 2153 is "considered worn out," finds no other apparent verification in the chemical analysis than this deficiency of phosphoric acid, which is also found in the other soils mentioned, except that its organic and volatile matters are in smaller proportions than in any of the other soils, and far below the average.

Notwithstanding these natural conditions, these soils, with good management, drainage where necessary, and the judicious use of fertilizers and a proper rotation of crops, can be made and kept quite productive.

HICKMAN COUNTY.

CLAYS.

No. 2161—"*Clay from chalk bluff, about two miles below Columbus.*" *Collected by John R. Procter.*

In moderately firm lumps, of a light buff and lead-grey color. Has a few ferruginous impressions of vegetable leaves. Seems

to be quite sandy, yet is quite plastic and burns hard, and of a very light cream color. Refractory before the blow-pipe, only sintering a little.

On washing the air-dried clay with water, it left about sixty-nine per cent. of very fine sand, of a drab color, containing a few very small spangles of mica.

No. 2162—"*Clay from the bluffs at Columbus, upper part of the town. Will it make fire-brick?*" *Collected by John R. Procter.*

In somewhat friable lumps, of a very light-grey color; almost white; quite sandy. Very little ochreous stain visible. It is plastic, and burns hard, of a light cream color, and is refractory before the blow-pipe. The air-dried clay, washed in water, left 68.5 per cent. of fine sand of a light-grey color, nearly white, which is composed of very small, rounded grains of quartz, with a few small specks of mica.

COMPOSITION OF THESE HICKMAN COUNTY CLAYS, DRIED AT 212° F.

	No. 2161.	No. 2162.
Silica	76.360	84.918
Alumina	14.951	10.560
Iron peroxide	2.109	1.102
Lime	.325	.572
Magnesia	.173	.108
Potash	1.171	.651
Soda	.125	not est.
Combined water and loss	4.786	2.089
Total	100.000	100.000

No doubt No. 2162, if it will burn hard enough, would make quite refractory fire-brick, and it, as well as the other clay, might be made available for terra-cotta and other forms of pottery ware. No. 2161 is less refractory, because, doubtless, of its larger proportions of iron peroxide and potash.

Under the head of Ballard county, a comparison was made of the composition of one of these refractory clays and that of the celebrated glass-pot clay of Germany, and the main difference between them was in the larger proportion of potash in the Ballard county clay. The same similarity of composition with the glass-pot clay may be observed in some of

the Fulton county clays, as well as in the above described. Whether this somewhat greater proportion of potash would be fatal to the application of these refractory clays in the glass-works, is worthy of practical trial on a small scale.

No. 2163—"*Sand from Columbus; above the town. A very large deposit.*" *Collected by John R. Procter.*

A nearly white sand, made up mostly of small, rounded grains of hyaline quartz, colored very light purplish with iron oxide, and containing a few friable concretions made by infiltration of carbonate of lime.

Washed in water, air-dried, it left 99.40 per cent. of nearly pure white sand. It is no doubt pure enough for the manufacture of any but the very finest kind of glass.

No. 2164—"SOIL, LABELED "*New soil; surface soil; two years in cultivation in corn. Thought to be the prevailing upland soil in the county.*" *Collected by John R. Procter.*

In friable clods of a grey umber-brown color. It all passed through the coarse sieve, and its silicious residue left on the bolting-cloth sieve only two or three small particles of partly-decomposed silicates.

COMPOSITION, DRIED AT 212° F.

Organic and volatile matters	4.140
Alumina and iron and manganese oxides	3.694
Lime carbonate	.495
Magnesia	.232
Phosphoric acid	.156
Potash extracted by acids	.182
Soda extracted by acids	.564
Water expelled at 380° F.	1.010
Sand and insoluble silicates	90.095
Total	100.568
Hygroscopic moisture	1.735
Potash in the insoluble silicates	1.899
Soda in the insoluble silicates	.573

Although the proportion of sand and insoluble silicates is larger than the average, this is a very good soil, containing

full average quantities of alkalies, phosphoric acid, and lime. Like most of our Kentucky soils, the silicious constituent is in such a fine state of division that it has many of the physical properties of fine clay, and would not, in ordinary parlance, be denominated sand.

JEFFERSON COUNTY.

CLAYS.

No. 2165—"*Shaly clay (or clay shale) in the limestone layers of the 'Cincinnati Group.' Lower Silurian. Jeffersontown.*" *Collected by Rev. H. Hertzer.*

A friable shale, generally of a lilac-grey color, but with some whitish portions. When powdered, it is quite plastic with water. It calcines of a light brick color; but before the blow-pipe it fuses into a dark-colored slag.

No. 2166—"*Shaly clay, of the Keokuk Group, from Cox's Knob. Jefferson county.*" *Collected by Rev. H. Hertzer.*

Generally of an olive-grey color. This also is quite plastic when powdered. It calcines of a very light brick color. Before the blow-pipe it fuses into a dark-colored slag.

No. 2167—"*Shaly clay (or clay shale) of the Keokuk Group. From the old Deposit Station. Jefferson county.*" *Collected by Rev. H. Hertzer.*

A friable shale or indurated clay of a light buff-grey color, with ferruginous stains between some of the laminæ.

Quite plastic when powdered. It burns of a light brick color, and fuses before the blow-pipe into a dark-colored slag.

COMPOSITION OF THESE SHALY CLAYS, DRIED AT 212° F.

	No. 2165.	No. 2166.	No. 2167.
Silica	47.960	58.840	61.900
Alumina with phosphoric acid	21.340	19.940	18.520
Iron peroxide	6.600	6.000	6.220
Lime	5.824	3.226	.123
Magnesia	3.524	.857	1.259
Potash	5.264	4.490	4.867
Soda	.250	.685	.612
Carbonic acid, undetermined, and water	9.238	5.962	6.499
Total	100.000	100.000	100.000

These indurated or shaly and marly clays, usually containing a notable proportion of the alkalies, potash and soda, as well as of lime and magnesia, with a variable small quantity of phosphoric acid, might, in some cases, be profitably applied as top-dressing to light soils which are deficient in clay, and which have become exhausted by culture. They could also be used for terra-cotta work, especially those which burn hard and of a handsome color. These might also be used for drain-tiles, flower-pots, and other forms of pottery. At a very high temperature, in the kiln, however, they would soften or melt.

MADISON COUNTY.

CLAYS.

No. 2168—"*Clay; Milton Barlow; from near Bybeetown. Bed four feet thick; in Black shale.*" *Collected by John R. Procter.*

Clay of a light, warm drab-grey color. Irregularly and imperfectly laminated. Quite plastic. Burns of a delicate light, reddish-cream color; nearly white. Before the blow-pipe it fuses into a whitish slag with difficulty.

No. 2169—"*Clay of workable thickness; on the road leading from Waco to R. Oldham's, about a mile and a half from Waco. Probably below the Corniferous limestone.*" *Collected by John R. Procter.*

A compact clay, generally of a light, olive-grey color, stained irregularly with ochreous and ferruginous. Quite plastic. Calcines quite hard, of a handsome light brick color. Before the blow-pipe it fuses into a brownish-grey slag.

No. 2170—"*Indurated clay; farm of C. L. Searcy, near Elliston. Beneath the Corniferous limestone. Bed ten feet thick or more. Makes a good soil.*" *Collected by John R. Procter.*

A light, olive-grey, laminated clay; mottled with ochreous or orange-colored ferruginous infiltrations. The laminæ are contorted. It is quite plastic. Burns of a handsome flesh-color. Fuses into a grey slag before the blow-pipe.

COMPOSITION OF THESE MADISON COUNTY CLAYS, DRIED AT 212° F.

	No. 2168.	No. 2169.	No. 2170.
Silica	62.560	64.566	62.580
Alumina	24.780	20.160	22.940
Iron peroxide	1.800	4.200	3.760
Lime	a trace.	.213	.560
Magnesia	.317	.641	.425
Potash	3.276	5.054	5.280
Soda	.294	not est.	.308
Combined water, &c., and loss	6.973	5.166	4.147
Total	100.000	100.000	100.000

These are good plastic clays for the manufacture of ordinary pottery ware, as well as for ornamental articles of terra-cotta, for which use they are adapted because of the pleasant tints they assume in calcination. They owe these tints to their considerable proportion of iron oxide, which, together with their large proportion of potash, renders them unavailable as fire-clays. This very circumstance, however, may fit them for stone-ware, and for superior kinds of hard, burnt, semi-fused, ornamental pottery in the hands of skillful workmen and artists.

MARLY SHALES OF MADISON COUNTY.

No. 2186—"*Marly shale; on the road near A. Lake's place; Drowning creek. 'Niagara Group.'*" *Collected by John R. Procter.*

An olive-grey and brownish-grey, somewhat firm shale, mottled in parts; adhering to the tongue. Quite plastic with water when powdered. Calcines of a light brick color. Fuses before the blow-pipe into a dark brown, nearly black slag.

No. 2187—"*Marly shale or indurated marly clay. On the hill two hundred yards north of Dr. Freeman's house. Probably the same bed as No. 2167, beneath the Corniferous limestone. The bed is six feet thick or more, and contains gypsum.*" *Collected by John R. Procter.*

Generally in thin, soft, irregular laminæ, of a light olive-grey color, irregularly varied with brownish yellow or ochre-

ous. It contains gypsum in irregular crystals between some of the laminæ; shows some fossil vegetable impressions, probably fucoid, on some of the layers.

It is quite plastic with water. Burns quite hard, of a handsome light brick color. Before the blow-pipe it melts into a dark brownish-green slag.

COMPOSITION OF THESE MARLY SHALES, DRIED AT 212° F.

	No. 2186.	No. 2187.
Silica	42.300	48.780
Alumina, &c.	20.840	17.320
Iron peroxide	4.120	3.240
Lime sulphate (gypsum)	.....	19.285
Lime	13.320	.....
Magnesia	.461	.496
Potash	2.387	4.768
Soda	.351	.240
Combined water, carbonic acid, and loss	16.221	5.871
Total	100.000	100.000

Because of the large proportion of gypsum (plaster of Paris) contained in No. 2187, and its considerable quantity of potash, it would no doubt prove a valuable top-dressing on soil and crops where the use of plaster is indicated. The shale No. 2186 would be useful on soils principally on account of the lime which it contains, which is equivalent to nearly twenty-four per cent of carbonate of lime.

No. 2188—A. "*Rock impregnated with Epsom salt, &c. C. L. Searcy's farm, near Elliston. Beneath the Corniferous limestone.*" *Collected by John R. Procter.*

A somewhat friable ferruginous sandstone, generally of a dull brown color, variegated somewhat with other tints. Showing minute crystalline specks in the cracks, and between the irregular laminæ. It contains irregular nodules of chert, infiltrated with bright iron pyrites.

B. Brown powder contained in the sample. Supposed to be the result of the disintegration of the rock by the crystalline force of the included salt.

The rock (A), when lixiviated with water, gave a solution which left, on evaporation and drying at the temperature of boiling water, as much as 4.8126 per cent. of the rock of *saline matters*, principally magnesia sulphate (Epsom salt), with small quantities of salts of lime, potash, soda, and iron.

The brown powder (B) was found to contain only 3.840 per cent. of *saline matters*, of similar composition. The rock was not submitted to analysis, but it is pretty evident that the Epsom salt and other sulphates were derived from the reaction of the oxidated iron pyrites on the bases contained in the rock.

LIMESTONES OF MADISON COUNTY.

No. 2189—"*Shelly limestone in the bed of Muddy creek; below J. Q. Compton's. 'Cumberland' shales? Probably Clinton.*" *Collected by John R. Procter.*

Of a dark umber-grey color. Generally quite friable; some portions are compact.

No. 2190—"*Impure limestone; top of the 'Cumberland' shales. Upper twelve inches. From below the mill-dam on Muddy creek, Elliston.*" *Collected by John R. Procter.*

A pretty firm, fine-granular, or compact rock, of a handsome light olive-grey color.

No. 2191—"*Impure limestone. Top of 'Cumberland' shales. From eighteen to thirty inches below the massive bluff limestone of the Upper Silurian on Muddy creek.*" *Collected by John R. Procter.*

Rather darker colored than the next preceding; color inclined to brownish; not so hard as that. It contains no bitumen, but some sulphur.

No. 2192—"*Impure limestone; resting on the top of the 'Cumberland' shales; bottom stratum. From below the mill-dam on Muddy creek.*" *Collected by Jno. R. Procter.*

A granular limestone; somewhat cellular; containing some petroleum, which gives it a brownish color. It weathers ochreous.

No. 2193—"*Impure limestone. Niagara. Top stratum, eight inches thick. From below the mill-dam on Muddy creek. Elliston.*" *Collected by John R. Procter.*

An impure granular limestone; somewhat cellular; dark brownish-grey, somewhat mottled. Contains petroleum, the infiltration of which gave the dark color to the rock. When heated over the spirit-lamp, the petroleum exudes from it. It weathers ferruginous.

No. 2194—"*Impure limestone. Second from the top. From just below the mill-dam on Muddy creek. Elliston.*" *Collected by John R. Procter.*

It resembles the preceding, but is darker colored; it also contains petroleum and some iron pyrites.

No. 2195—"*Impure limestone. Niagara. Third stratum from the top. From below the mill-dam, Muddy creek. Elliston.*" *Collected by John R. Procter.*

Resembles the preceding; rather finer-grained and harder; also containing petroleum. Exterior surface weathered ferruginous.

No. 2196—"*Impure limestone. Clinton Group? From the quarry north of Rogersville. This rock makes good soil.*" *Collected by John R. Procter.*

A compact or fine granular rock; non-fossiliferous; of an olive-grey color; in some parts brownish. Not adhering to the tongue. It contains no petroleum, but some pyrites.

No. 2197—"*Limestone from below the Cauda-galli grit, at the base of the Corniferous limestone.*" *Collected by John R. Procter.*

A fine granular, brownish-grey rock. It gives the odor of petroleum when heated, and probably owes its brownish tint to a small quantity of this substance.

No. 2198—"*Bituminous limestone from above the Corniferous limestone; three to ten feet thick; from near Elliston.*" *Collected by John R. Procter.*

Generally of a dull, brownish-black, or grey-black color. Some pieces with bands of a lighter grey tint. It is a fine granular rock.

No. 2199—"*Impure limestones. Top of the Corniferous limestone. Total thickness fifteen feet; with intercalated beds of purer limestone six inches thick.*" *Collected by John R. Procter.*

A tough, fine granular or compact rock. Samples from different levels are mixed; some of which are brownish-black, some umber colored, and some intermediate in tint.

No. 2200—"*Limestone; on the road one mile south of Mrs. S. J. Embry's; intercalated with the so-called Black Band, or bituminous limestone. To be tested for hydraulic properties.*" *Collected by John R. Procter.*

A dull buff-grey, fine granular rock, with some little infiltration of hydrated iron oxide.

COMPOSITION OF THESE MADISON COUNTY LIMESTONES, DRIED AT 212° F.

	No. 2189	No. 2190	No. 2191	No. 2192	No. 2193	No. 2194	No. 2195	No. 2196	No. 2197	No. 2198	No. 2199	No. 2200
Lime carbonate	48.530	37.760	33.560	45.700	50.860	50.970	51.200	35.160	43.060	41.150	36.580	47.580
Magnesia carbonate. . .	11.790	10.050	6.855	27.475	20.100	27.972	25.124	4.645	9.994	13.908	18.541	17.133
Alumina		17.656	21.256				12.360	10.706				
Phosphoric acid. . . .	10.330	.204	.204	11.360	9.960	5.960	.140	.754	9.420	9.040	4.010	10.980
Iron peroxide. .		3.700	4.120	3.500*	3.900	3.556	4.460	2.060	2.640	1.890	1.540	
Iron sulphide	. . . .	. . . .	. . . .	. . . .	. . . .	.576	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Potash	1.696	.458	.578	.501	.276	.276	.287	2.033	.770			
Soda	.347	.090	.045	.088	.054	.087	.049	.586	.149	13.022	7.339	not est.
Bitumen, water, and loss,	. . . .	. . . .	. . . .	1.396	10.870	6.493	2.460	. . . .	11.287			
Water and loss	6.567	4.902	4.302	. . . .	. . . .	. . . .	. . . .	4.275	. . . .	. . . .	. . . .	6.117
Silicious residue	20.740	25.180	29.080	9.980	3.980	4.120	3.920	39.780	22.680	20.990	31.990	18.190
Total	100.000	100.090	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
Percentage of lime . . .	27.173	21.145	18.794	25.592	28.480	28.538	28.672	19.689	24.113	23.044	20.485	26 645
Percentage of magnesia .	5.614	4.785	3.251	13.083	9.608	13.319	11.899	2.212	4.756	6.384	8.781	8.158
Percentage of silica. . .	not est	20.980	22.8 0	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.

* Mostly Ferrous oxide in the rock.

These impure limestones vary considerably in their composition and properties. Nos. 2192, 2193, 2194, and 2195, from the Upper Silurian strata, are quite magnesian, and contain considerable proportions of alumina and iron oxide, with but a moderate quantity of silicious matter. Many of these magnesian limestones make quite good and durable building stone; but this depends greatly on the mechanical structure of the rock. The magnesian limestones also make good quicklime when pure, and when silicious or containing much clay, frequently prove to be good water-limes. A very imperfect trial of No. 2195, by calcining a small quantity, proved that it would harden in contact with water; but whether it would become very hard by time, or prove durable, was not ascertained. Possibly greater care in the experiment, in the burning, &c., with more time, would give a more satisfactory result. Its proportion of silica, however, is quite small.

The rest of these limestones were not tried in this relation, except Nos. 2189, 2190, and 2200, and these did not harden in a satisfactory manner in water. As all of these contain quite a large proportion of aluminous and silicious matters, if they would make water cement at all, it would be of the slowly-setting variety, like the artificial Portland cement, for the manufacture of which, with or without the addition of more lime, they might possibly be made available.

Specimens of Corniferous and Silurian limestones, showing bright olive-green blotches, specks, and grains, were sent to the laboratory to ascertain their nature. This green material, frequently found in a granular form, is the mineral glauconite, the main constituent of the green sand of the cretaceous formation, described in a previous chemical report under the number 2067.

IRON ORES FROM MADISON COUNTY—BOG IRON ORES.

No. 2201—"*Bog ore from near R. Dudley's, half a mile south of the Richmond and Irvine Turnpike. A thick deposit, on the Black Shale formation.*" *Collected by John R. Procter.*

Mostly soft ochreous material of different light tints, mixed

irregularly with some curved laminæ of more compact, dark colored limonite.

No. 2202—"*Bog ore; Black Shale formation; on the lands of T. P. Estill and M. T. Todd. Two hundred yards south of the Richmond and Irvine Turnpike, near Ross' blacksmith shop. Bed of workable thickness.*" *Collected by John R. Procter.*

Resembles the preceding, but is somewhat darker colored, and has more of the hard, irregular limonite layers.

No. 2203—"*Bog ore; on the Black Shale formation; a good deposit. Near Mrs. Tudor's, on the Richmond and Irvine Turnpike.*" *Collected by John R. Procter.*

Resembles the preceding. The samples are from different outcrops of the same bed, which seems to have considerable extent.

No. 2204—"*Bog ore; a thick deposit on the road to Red river, near T. Lewis', half a mile west of Harris' ferry, one mile from Kentucky river. Resting on Corniferous.*" *Collected by John R. Procter.*

Generally of a dull black color, like earthy manganese peroxide, with some little reddish and yellowish ochreous material intermixed.

COMPOSITION OF THESE BOG ORES, DRIED AT 212° F.

	No. 2201.	No. 2202.	No. 2203.	No. 2204.
Iron peroxide	28.440	19.800	30.870	17.300
Alumina and phosphoric acid	5.240	9.880	11.560	14.820
Lime carbonate	.190	.380	.290	.130
Magnesia carbonate	1.279	1.844	.897	1.041
Silicious residue	56.220	62.290	49.980	56.260
Water, alkalies, &c., and loss	8.631	5.806	6.403	10.449
Total	100.000	100.000	100.000	100.000
Percentage of iron	19.890	13.860	21.570	12.110

Generally too poor to be profitably smelted by themselves for iron; although some of them might be used in mixture with richer ores, provided the phosphoric acid is not in too

large proportion. The ore varies considerably in different parts of the bed, and in some localities it might, no doubt, yield material for cheap mineral paint.

No. 2205—"*Ferruginous shale. Labeled 'Black Band ore.' W. B. Combs' Knob. Resting on the top of the coal.*" *Collected by John R. Procter.*

A somewhat compact, ferruginous shale, of a dull brownish-black color, spangled with fine scales of mica. Weathers ferruginous.

COMPOSITION, DRIED AT 212° F.

Iron oxide	19.500, containing 13.650 per cent. of iron.
Alumina and phosphoric acid	16.360
Lime	trace.
Magnesia	trace.
Silicious residue	39.940, containing 32.300 per cent. of silica.
Bituminous matter, water, and loss.	24.200
Total	100.000

Too poor to be called an iron ore.

SOILS FROM MADISON COUNTY.

No. 2206—"*Top soil from the farm of J. G. Covington, Muddy creek. Probably Clinton shales, above the Cincinnati Group. Has been in cultivation for twenty-six years in corn, with but two crops of small grain. With an average yield all the time of sixty bushels of corn to the acre. Lies above the overflow.*" *Collected by John R. Procter.*

Dried soil of a brownish-umber color; pretty friable. It all passed through the coarse sieve except a small proportion of small ferruginous concretions, and some few small rounded pebbles of reddish quartz. The bolting-cloth separated from its silicious residue a small proportion of small rounded white quartz grains, and very few of partly-decomposed concretions.

No. 2207—"*Subsoil from the same field, taken one foot below the surface,*" *&c., &c.*

The dried subsoil is very slightly darker colored than the surface soil, and the clods are firmer. It all passed through

the coarse sieve except a small proportion of small ferruginous concretions, somewhat rounded. The bolting-cloth separated from its silicious residue a rather larger proportion of small, rounded white quartz grains than from the preceding, but very few grains of partly-decomposed concretions.

No. 2208—"*Bottom clay under the two preceding*," *&c., &c.*

The dried under-clay is of a handsome brownish-yellow ochre color. It is in pretty firm clods. It all passed through the coarse sieve except a small proportion of small ferruginous concretions, and a few small white quartz pebbles. The bolting-cloth removed from its silicious residue a small proportion of small, rounded white quartz grains, and a few of partly-decomposed concretions; a smaller quantity than from the preceding.

COMPOSITION OF THESE MADISON COUNTY SOILS, DRIED AT 212° F.

	No. 2206.	No. 2207.	No. 2208.
Organic and volatile matters	7.240	7.150	2.950
Alumina and iron and manganese oxides	10.353	10.905	11.032
Lime carbonate	2.485	1.870	.220
Magnesia	.989	.809	.160
Phosphoric acid	.387	.300	.173
Potash extracted by acids	.545	.638	.359
Soda extracted by acids	.162	. . . . .	. . . . .
Water expelled at 380° F.	1.122	1.450	.800
Sand and insoluble silicates	76.715	77.395	84.174
Total	99.998	100.517	99.868
Hygroscopic moisture	3.275	3.775	2.575
Potash in the insoluble silicates	1.949	2.079	1.800
Soda in the insoluble silicates	.206	.281	.407
Character of the soil	Cultivated field.	Subsoil.	Under-clay

The upper soil and subsoil present in their composition all the characteristics of very fertile soil. The under-clay is not so rich as these.

WATER FROM MADISON COUNTY.

No. 2209—"*Sulphur water from a spring on the farm of C. L. Searcy, Elliston. In the Niagara Group.*" *Collected by John R. Procter.*

The water was brought to the laboratory in a jug and bottle, both well corked. It retained a slight odor of hydrogen sulphide, and was slightly opalescent from a light precipitate of sulphur. It had deposited a dark sediment, and the corks were slightly blackened, as from the presence of iron. Testing showed it to be slightly alkaline in reaction.

COMPOSITION OF SALINE CONTENTS OF THIS WATER, in 1000 PARTS.

Lime carbonate	0.2040	Held in solution by carbonic acid.
Magnesia carbonate	.0322	
Iron carbonate and phosphoric acid	.0172	
Silica	.0045	
Lime sulphate	.4301	Left dissolved in the water after long boiling.
Calcium chloride	.0124	
Magnesium chloride	.0920	
Potassium chloride	.0380	
Sodium chloride	.3221	
Soda carbonate	.0937	
Silica	.0018	
Lithium, strontium, and sodium sulphide	traces	
Organic matters and loss	.3294	
Total solid matters in 1000 parts of the water	1.5774	

The water also contained free carbonic acid, and, at the spring, no doubt, a notable amount of hydrogen sulphide; but the quantity of these gases could only be correctly estimated at the source. It seems to be a good saline sulphur water, containing a small quantity of iron, which would add to its medicinal utility.

No. 2210—"*Water from an Artesian well one hundred and twenty-six feet deep. Bored in the rocks of the Upper Cincinnati Group. About one hundred and fifty feet south of the railroad track at Clear Creek Station, and about two hundred and fifty feet west of Silver creek, in a bottom. The water stands in the well at thirty-five feet from the surface.*" *Sent by John R. Procter.*

On evaporation to dryness, this water left 0.4658 of a

gramme of saline matters, &c., dried at 212°, to the thousand of the water.

The *composition* of which saline matter is as follows:

Lime carbonate	0.1550	Held in solution by carbonic acid.
Magnesia carbonate	.0503	
Iron carbonate and silica	n. e.	
Lime sulphate	.0350	
Potash sulphate	.0124	
Soda sulphate	.0096	
Sodium chloride	.1467	
Silica	.0060	
Moisture and loss	.0508	
Total saline matters in 1000 parts of the water	0.4658	

This is what is called a "hard" water; but it contains no organic matters or other injurious ingredient. Its small proportion of sulphate of lime would only tend to form a hard crust in steam-boilers when it was used in them for too long a time without "blowing out."

The water of Silver creek was tested at the same time with the above described; also that of a well in the creek; both at the Silver Creek Distillery, Madison county.

The Silver creek water left, on evaporation, 0.1772 per 1000 of solid saline matters, slightly stained with organic matters.

The well water left 0.2212 per 1000 of the water of saline matters, which also showed a trace of organic matter. The composition appeared to be similar to that of the saline matter of the Artesian well water.

McCRACKEN COUNTY.

No. 2211—"*Fire-clay, three and three quarters miles south of Paducah, on the Mayfield road.*" *Collected by John R. Procter.*

In friable lumps, generally of a very light grey color, nearly white, mottled with a very light ochreous material.

It is quite plastic. Before the blow-pipe it burnt hard, of a light grey color, nearly white, and finally fused with great difficulty.

COMPOSITION, DRIED AT 212° F.

Silica	64.480
Alumina with trace phosphoric acid	24.691
Iron peroxide	1.869
Lime	.448
Magnesia	.137
Potash	1.457
Soda	.083
Combined water and loss	6.835
Total	100.000

While this clay would answer well for the manufacture of ordinary fire-brick, and of rather superior varieties of pottery-ware, terra-cotta, &c., its considerable proportions of potash and iron peroxide might cause it to soften when exposed to a very intense heat.

No. 2212—"*Subsoil from land of Dr. S. B. Caldwell, two miles southwest of Paducah, McCracken county. This earth, when dug up and spread upon the land, produces good results. Quaternary.*" *Collected by John R. Procter.*

The dried soil is friable, and of a light brownish-grey color. The coarse sieve removed from it some friable shot iron ore, and a small silicious fragment. All its silicious residue passed through the bolting-cloth, except a very few small, rounded grains of hyaline quartz.

COMPOSITION OF THIS SUBSOIL, DRIED AT 212° F.

Organic and volatile matters	1.840	
Alumina and iron and manganese oxides	5.883	
Lime carbonate	.070	
Magnesia	.200	
Phosphoric acid	.082	
Potash extracted by acids	.186	
Soda extracted by acids	.314	
Water expelled at 380°	.485	Containing:
Sand and insoluble silicates	90.920	Potash=1.773
		Soda = .855
Total	99.980	

Hygroscopic moisture = 1.500 per cent.

No reason appears in the chemical composition of this earth why it should act as a fertilizer, except when plentifully applied on poor light soils.

NELSON COUNTY.

SOILS.

No. 2213—"*Soil from a field on the farm of Mr. James R. Ballard, two miles northwest of Rohan's Knob. The field has not been wasted much by cultivation, but in washing away. Timber, mostly white oak and ash. Bed rock, black slate and Corniferous limestone.*" *Collected by John R. Procter.*

The dried soil is friable, and of a reddish, light brownish tint. The coarse sieve separated from it 1.5 per cent. of its weight of small, partly-rounded ferruginous fragments. Its silicious residue, from digestion in acids, all passed through the fine sieve (1,600 meshes to the centimeter square), except a small proportion of small particles of partly-decomposed concretions, and a few small grains of white quartz.

No. 2214—"*Subsoil of the next preceding, ten inches from the surface,*" *&c.*

The dried subsoil is lighter colored and more yellowish than the preceding. Of a light brick color. Its clods are quite firm. The coarse sieve separated from it only 0.5 per cent. of small ferruginous fragments, partly rounded. The fine sieve, with 1,600 meshes to the centimetre square, separated from its silicious residue a considerable proportion of small particles of partly-decomposed concretions, and only one or two small silicious grains.

No. 2215—"*Bottom soil or under-clay of the next preceding, two feet from the surface; not penetrated by roots.*" *Collected by John R. Procter.*

The dried soil is of a handsome light brownish orange-red color, or handsome light brick color. The coarse sieve separated from it 1 per cent. of small irregular quartz pebbles. The fine sieve removed from its silicious residue a small proportion of small particles of partly-decomposed concretions, and of rounded quartz grains, with a few minute silicified joints of encrinital stems.

COMPOSITION OF THESE NELSON COUNTY SOILS, DRIED AT 212° F.

	No. 2213.	No. 2214.	No. 2215.
Organic and volatile matters	3.360	2.990	3.300
Alumina and iron and manganese oxides	7.977	10.349	14.368
Lime carbonate	.270	.245	.880
Magnesia	.166	.187	.809
Phosphoric acid	.108	.061	.102
Potash extracted by acids	.116	.164	.361
Soda extracted by acids	.225	.045	.657
Water expelled at 380° F.	1.215	.900	2.415
Sand and insoluble silicates	86.650	85.075	76.840
Total	100.087	100.016	99.732
Hygroscopic moisture	1.485	2.525	1.129
Potash in the insoluble silicates	1.669	1.835	2.742
Soda in the insoluble silicates	.274	.400	.225
Percentage of gravel	1.400	.500	1.000
Character of the soil	Surface soil	Subsoil.	Under-clay

These soils are of good average fertility, judging from their chemical composition and physical constitution. The only apparent deficiency is of phosphoric acid in the subsoil No. 2214. This, however, is easily to be supplied in phosphatic fertilizers. The under-clay is chemically richer than the upper soil.

Some of the *silicious residue* of the "under-clay" was submitted to analysis by fusion with the alkaline carbonates, &c., with the following results, viz:

CONSTITUENTS OF ONE GRAMME OF THE *SILICIOUS RESIDUE* OF THE UNDER-CLAY, No. 2215, DRIED AT 212° F.

Silica	0.76880
Alumina and iron oxide, &c.	.18920
Lime	.00061
Magnesia	.00569
Phosphoric acid	.00051
Potash	.02742
Soda	.00225
Moisture and loss	.00552
Total	1.00000

This analysis shows that the silicious residue of this under-clay not only contains 2.742 per cent. of potash, but as much

as .05 per cent. of phosphoric acid, besides notable quantities of alumina, lime, and magnesia. Its gradual decomposition by weathering would undoubtedly tend to maintain the fertility of the soil. Under Fulton county the analyses of other silicious residues are reported which gave analogous results.

No. 2216—"*Marly clay at the base of Carboniferous series; probably on the Keokuk horizon. Part of the section contains thin beds of clay iron-stone; but beds of many feet in thickness can be obtained. Nelson county.*" *Collected by N. S. Shaler.*

This clay is quite plastic, when powdered, and calcines of a buff color. Before the blow-pipe it fuses into a dark colored slag.

COMPOSITION, DRIED AT 212° F.

Silica	61.100
Alumina with phosphoric acid	18.200
Iron peroxide	6.000
Lime	4.904
Magnesia	1.542
Potash	4.101
Soda	.821
Combined water, carbonic acid, and loss	3.332
Total	100.000

This clay may be employed for terra-cotta work or other pottery not to be exposed to a very high temperature in burning; but its large proportions of iron oxide, lime, potash, magnesia, and soda cause it to be readily fusible. Its proportion of phosphoric acid was not determined, but its other ingredients, mentioned above, especially the alkalies and lime, may make it a valuable marl for top-dressing light and exhausted soils.

PULASKI COUNTY.

SOILS.

No. 2217—"*Virgin soil from a ridge near the farm of Mr. Taylor, on the London and Somerset road. This ridge divides the waters of Sinking Valley creek. Geological position: one hundred and fifty feet above the Sub-carboniferous limestone, the ridge being formed of the coal-bearing sandstones and slates. Very thin poor land. Scarcely any one is willing to settle on this kind of ridges.*" *Collected by Joseph Lesley, jr., July*, 1859 (*during the former Survey under the late Dr. D. D. Owen*).

The dried soil is of a grey-buff color; friable. The coarse sieve removed from it 31.6 per cent. of irregular fragments of ferruginous sandstone. Only the fine soil, which passed through this sieve, constituting 68.4 per cent. of the whole soil, was taken for chemical analysis. The same practice obtained in all cases.

The silicious residue of this soil, left after digestion in acids, with a view to its analysis, all passed through the bolting-cloth, except a very few small particles of partly-decomposed concretions and of rounded quartz grains.

No. 2218—"*Virgin soil from a ridge dividing Rockcastle from Buck creek waters; Lick creek, Clifty creek, Whetstone creek, and a branch of Sinking creek, all heading in this immediate neighborhood. Geological position: upper part of the coal-bearing sandstones and shales. This ridge extends twenty to twenty-five miles in a southerly direction.*" *Collected by Jos. Lesley, jr., June*, 1859.

The dried soil is of a brownish grey-buff color. It contains few clods, which are quite friable. The coarse sieve separated from it 9.2 per cent. of irregular fragments of ferruginous sandstone, scarcely at all rounded. All its silicious residue passed through the bolting-cloth, except two or three small particles of partly-decomposed concretions, and a few small rounded grains of white quartz.

No. 2219—"*Surface soil from a field now* (1859) *in corn, adjoining the location of the next preceding. It has been cleared eight years. Will produce twenty-five bushels of corn to the acre. Alternation of crops has been attended to.*" *Collected by Jos. Lesley, jr.*

The dried soil is friable, darker colored than the preceding; of a light umber tint. The coarse sieve separated from it 19.2 per cent. of irregular, somewhat rounded fragments of ferruginous sandstone. From its silicious residue the bolting-cloth separated a little more of small, rounded particles of white quartz than from the preceding, but very few of partly-decomposed concretions.

No. 2220—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil is of a light brownish or ferruginous grey tint, lighter in color than the preceding. It contains many fragments of rock. The coarse sieve separated 34.7 per cent. of irregular fragments of ferruginous sandstone. The bolting-cloth separated from the silicious residue rather more of small rounded quartz grains than from the preceding, and a few more of small particles of partly-decomposed concretions.

No. 2221—"*Virgin soil from the farm of Owen Hunt, two miles and a half east of Grundy; six miles northeast of Somerset; on Blazed Hollow branch of Pitman's creek. Geological position: slopes formed of Sub-carboniferous limestone.*" *Collected by Joseph Lesley, jr.*

The dried soil is quite light and friable, of a light brownish-grey color. The coarse sieve removed from it 13.8 per cent. of small, rounded quartz pebbles, with a few of small scarcely-rounded fragments of ferruginous sandstone. Its silicious residue, after digestion in acids, left on the bolting-cloth a rather larger proportion of small, rounded grains of whitish and reddish quartz than the preceding soils, also a few particles of partly-decomposed concretions.

No. 2222—"*Surface soil from a field adjoining the locality of the next preceding, which has been in cultivation about seventy-five years; in crops alternating with corn, wheat, and oats; now (June, 1859) in corn, which will yield about thirty bushels to the acre. Cattle have been turned on sparingly. Has been plowed deep for Eastern Kentucky, to the depth of eight to nine inches.*" *Collected by Joseph Lesley, jr.*

The dried soil is of a dark brownish-grey color, darker than the preceding. Friable. The coarse sieve removed from it 15 per cent. of small quartz pebbles and sandstone fragments; the pebbles not being so large proportion as in the preceding soil. The bolting-cloth separated from its silicious residue about the same proportion of small rounded grains of whitish and reddish quartz, and of partly-decomposed concretions, as from the preceding.

No. 2223—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil is of a lighter brownish grey than the preceding. Contains moderately firm clods.

The coarse sieve separated only 3.1 per cent. of small somewhat rounded fragments of ferruginous sandstone mixed with a very few small quartz pebbles. All its silicious residue passed through the bolting cloth, except a rather small quantity of fine white sand, and rather more of small particles of partly-decomposed concretions than from the preceding.

No. 2224—"*Under-clay taken from below the next preceding to show the clayey nature of the real under-soil of these limestone valleys. Sample taken from the depth of twelve to fifteen inches.*" *Collected by Jos. Lesley, jr.*

This dried under-clay is of a light brownish-ochre color. The clods are quite firm. The coarse sieve separated from it 4.5 per cent., mostly of small quartz pebbles. From its silicious residue the bolting-cloth removed a considerable proportion of small grains of partly-decomposed concretions and a few of reddish and whitish quartz.

No. 2225—"*Virgin soil from the farm of James Denny, on the border of Wayne county, seven miles south of Somerset, one mile from the forks of the main Cumberland and Big South Fork. Geological position: Sub-carboniferous limestone formation. Note: This is a characteristic soil of the 'Barrens' of Pulaski and Wayne counties. The 'Barrens' form a strip of the first great terrace above and south of the Cumberland river, averaging five miles in width and extending lengthwise from the forks of the Cumberland to and beyond Monticello. Fifty years ago they were open prairie, with only occasional high swells, covered with black oak timber; now they are covered, where not cultivated, with a fine 'second growth,' mostly of black oak and hickory, with scattering dogwood and black gum.*" *Collected by Joseph Lesley, jr.*

The dried soil is friable, of an umber-grey color. The coarse sieve removed from it 8 per cent. of angular cherty particles, mixed with a little shot iron ore. All of its silicious residue passed through the bolting-cloth except a small proportion of hard, irregular particles of partly-decomposed concretions, and a small quantity of small, rounded grains of white quartz.

No. 2226—"*Surface soil from a field adjoining the locality of the next preceding. This field has been cleared up three years, and been planted in corn each year; plowed shallow; no manure used.*" *Collected by Joseph Lesley, jr.*

The dried soil is friable, of a light chocolate tint, deeper colored than the next preceding. The coarse sieve removed from it only 1.5 per cent. of cherty particles. Its silicious residue left on the bolting-cloth but a small proportion of small particles of partly-decomposed concretions and of small quartz grains.

No. 2227—"*Subsoil of the next preceding,*" *&c., &c.*

The dried subsoil contains some friable clods. It is of a slightly darker color than the next preceding. The coarse

sieve removed but a very small proportion of small, cherty fragments.

From its silicious residue the bolting-cloth separated a considerable proportion of small, rounded particles of partly-decomposed concretions, mixed with a small quantity of small, rounded grains of white quartz.

No. 2228—"*Surface soil from another field adjoining the locality of No.* 2225. *This field has been in active cultivation for fifty to sixty years, with the exception of the last two years. It is now* (1859) *in pasture* (*viz: pennyroyal and crab grass*)." *Collected by Joseph Lesley, jr.*

The dried soil is friable, and of a light chocolate color. The coarse sieve removed from it but a very small proportion of shot iron ore, with a few small, cherty particles. The bolting-cloth separated from its silicious residue only a small proportion of small quartzose and silicate grains.

No. 2229—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil contains some friable clods. It is darker colored and more reddish than the preceding, being of a warm or reddish-brown color. The coarse sieve removed from it but a very small proportion of small, angular, cherty fragments and shot iron ore. From its silicious residue the bolting-cloth separated a considerable quantity of small, rounded particles of partly-decomposed concretions, mixed with a small proportion of small, rounded grains of white quartz.

A marked difference is observable in the rocky fragments or gravel of these different soils. In the "ridge" soils, Nos. 2217 to 2220, inclusive, these are generally angular fragments of ferruginous sandstone; in the Sub-carboniferous soils, Nos. 2221 to 2224, inclusive, the gravel is mainly quartzose pebbles, with but little of ferruginous sand rock or concretions; while in the "Barrens" soils, Nos. 2225 to 2229, inclusive, the gravel is cherty, and usually in angular fragments.

COMPOSITION OF THESE PULASKI COUNTY SOILS, DRIED AT 212° F.

	No. 2217	No. 2218	No. 2219	No. 2220	No. 2221	No. 2222	No. 2223	No. 2224	No. 2225	No. 2226	No 2227	No. 2228	No. 2229
Organic and volatile matters	3.890	4.200	6.375	3.260	2.135	2.550	2.140	2.225	4.590	5.615	3.790	4.300	3.700
Alumina and iron and manganese oxides.	5.661	5.640	6.726	7.894	4.090	5.109	6.240	7.767	4.938	7.072	7.847	8.282	8.923
Lime carbonate	.125	.095	.345	.095	.170	.245	.170	.195	.220	.295	.130	.310	.220
Magnesia	.088	.070	.124	124	.052	.097	.128	.213	.115	146	.122	.115	.115
Phosphoric acid	.089	.045	.059	.076	.045	.076	.045	.083	.087	.118	.093	.148	.077
Potash extracted by acids	.345	.222	.277	.066	.147	.151	.217	.351	.145	100	.213	.149	.149
Soda extracted by acids	.027	. . . . .	.139	.256	.071	.060	.083	. . . . .	.089	.084	. . . . .	. . . . .	. . . . .
Water expelled at 380° F	.925	1.000	1.425	.790	.525	.650	.560	.525	1.535	1.985	1.400	1.700	1.550
Sand and insoluble silicates	88.690	88.765	84 350	87.640	92.765	91.240	90.540	88.790	88.340	84.500	86.675	84.990	85.490
Total	99.840	100.037	99.820	100.201	100.000	100.178	100.123	100.149	100.059	99.915	100.270	99.994	100.224
Hygroscopic moisture	0.915	1.315	1.900	1.235	2.135	0.900	0.965	0.775	1.750	1.525	1.200	1.225	1.340
Potash in the insoluble silicates	.642	.927	.852	.878	.778	.967	1.047	1.237	.953	.863	.762	.826	.795
Soda in the insoluble silicates	.205	.287	.139	.220	.260	.340	.340	.289	.223	.199	.230	.167	.160
Percentage of gravel, &c., in the soil	31.600	9.200	19.200	34.700	13.800	15.000	3.100	4.500	8.000	1.500	Sma'l p'n	Small p n.	Small p'n.
Character of the soil	Virgin soil	Virgin soil	Cultivated field.	Subsoil.	Virgin soil	Old field soil.	Subsoil.	Under-clay.	Virgin soil	Cu'tivated field.	Subsoil.	Old field soil.	Subsoil.

When we discount the ridge soil, No. 2217, by the 31.60 per cent. of sandstone fragments which it contains, and which could hardly afford much vegetable nourishment, we see that it cannot be a very durable and productive soil, yet if its local situation were favorable to the cultivation of crops, it might be made durable and profitably fertile with skillful management and the use of fertilizers. The principal deficiency in the fine earth of these soils seems to be of phosphoric acid. Subsoil No. 2220 not only contains a very large proportion of the rocky gravel, 34.70 per cent., but is also deficient in phosphoric acid and available potash. It would not benefit the surface soil to throw up this subsoil. The proportion of alkalies in the insoluble silicates seems to be below the general average of good soils.

Soils No. 2221, 2222, and 2223 also contain but a small proportion of phosphoric acid, but have a larger quantity of potash. Their sand and insoluble silicates are in large proportion. The soils from the "Barrens" are richer than these others, and ought to be quite productive under good management. These subsoils seem to be somewhat deficient in phosphoric acid, which is in good average proportion in the surface soils.

ROCKCASTLE COUNTY.

SOILS.

No. 2230—"*Virgin soil from the nose of the ridge between the East and West Forks of Skeggs' creek, and from the land of Halbert McClure. Geological position: coal-bearing sandstones and shales, one hundred feet above the Sub-carboniferous limestone, from a terrace containing coal.*" *Collected by Jos. Lesley, jr., June,* 1859.

The dried soil is light and friable. It is of a light chocolate yellowish-grey color. The coarse sieve separated from it 14.5 per cent. of small irregular somewhat rounded fragments of soft ferruginous sandstone. All its silicious residue, from digestion in acids, passed through the bolting-cloth, except a very few small grains of partly-decomposed concretions and a few small rounded quartz grains.

No. 2231—"*Virgin soil from a ridge in the northeast corner of Rockcastle county, which divides the waters of Clear and Brush creeks; both tributaries to Roundstone creek. Timber: chestnut oak and white oak, with undergrowth of laurel and some pine. Geological position: Millstone grit, which, on this ridge and on parallel ones in this part of the country, forms the capping.*" *Collected by Joseph Lesley, jr.*

The dried soil is of a grey-buff color; it is quite friable. The coarse sieve separated 21.4 per cent. of irregular fragments of ferruginous sandstone and some small, rounded pebbles of white quartz. The bolting-cloth removed very few small grains of partly-decomposed concretions from its sand and insoluble silicates left after digestion in acids, but a pretty large proportion, about one sixth of the whole, of small, rounded white quartz grains.

No. 2232—"*Virgin soil from the farm of William M. Smith, on the Crab Orchard and London Turnpike, three miles east of Mount Vernon. Taylor's branch of Roundstone creek runs through the field. Geological position: slopes of the Sub-carboniferous limestone. These slopes form the principal part of the farmed land on Roundstone, Skegg's, and Line creeks and their tributaries in this part of Rockcastle county. The northern slopes of the valleys are considered the best.*" *Collected by Joseph Lesley, jr.*

The dried soil is darker colored than the preceding. It is of a brownish grey-buff color. Its clods are friable. The coarse sieve removed from it 12.5 per cent. of irregular, somewhat rounded fragments of ferruginous sandstone. The bolting-cloth separated from its silicious residue but a small proportion of small particles of partly-decomposed concretions and of fine, rounded grains of white and reddish quartz.

No. 2233—"*Surface soil from a field adjoining the next preceding. This field was cleared up thirty years ago, and is now* (1859) *in oats. It was supposed to be worn out when Mr. Smith took it; has been manured, and now yields fifty bushels of corn per acre.*" *Collected by Joseph Lesley, jr.*

The dried soil is darker colored and more brownish than

the next preceding. Its clods are friable. The coarse sieve removed from it 17.4 per cent. of irregular fragments, somewhat rounded, of soft ferruginous sandstone. Its sand and insoluble silicates all passed through the bolting-cloth except a very small proportion of small grains of partly-decomposed concretions and of white quartz.

No. 2234—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil resembles the next preceding soil, but is a little darker colored, and its clods are quite firm. The coarse sieve removed from it 12 per cent. of irregular fragments, somewhat rounded, of soft, ferruginous sandstone. The bolting-cloth separated rather more of small, rounded grains of white quartz from its silicious residue than from the preceding, but very few small grains of partly-decomposed concretions.

No. 2235—"*Surface soil of a field in pasture adjoining No. 2233. This field has been cleared up sixty years, and only manured on the very bare spots.*" *Collected by Joseph Lesley, jr.*

The dried soil is of a very light chocolate tint, but somewhat darker in color than the next preceding. The coarse sieve separated from it 29 per cent. of irregular fragments of soft ferruginous sandstone. Its silicious residue all passed through the bolting-cloth, except a few small, soft grains of partly-dissolved concretions, and a very small proportion of small, rounded white quartz grains.

No. 2236—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil resembles No. 2232. The coarse sieve removed 28.6 per cent. of irregular fragments of soft ferruginous sandstone, with some fragments of limonite, and a few quartzose pebbles. All its silicious residue passed through the bolting-cloth, except a small proportion of grains of partly-decomposed concretions, and of white quartz.

COMPOSITION OF THESE ROCKCASTLE COUNTY SOILS, DRIED AT 212° F.

	No. 2230	No. 2231	No. 2232	No. 2233	No. 2234	No. 2235	No. 2236
Organic and volatile matters	6.890	4.150	4.950	6.065	4.265	4.500	3.360
Alumina & iron & manganese oxides	7.126	3.877	7.342	8.565	8.490	7.097	7.025
Lime carbonate	.345	.085	.435	.640	.625	.495	.395
Magnesia	.223	.120	.232	.153	.175	.130	.187
Phosphoric acid	.109	.083	.093	.140	.220	.173	.125
Potash extracted by acids	.366	.100	.231	.339	.453	.208	.254
Soda extracted by acids	.093	.....	.008	.....	.125	.002	.031
Water expelled at 380° F.	1.925	.750	1.300	1.650	1.375	1.300	.965
Sand and insoluble silicates	82.690	90.065	85.065	82.040	83.890	85.980	87.690
Total	99.767	99.830	99.656	99.598	99.618	99.885	100.032
Hygroscopic moisture	2.085	0.900	1.775	2.225	1.915	1.510	1.250
Potash in the insoluble silicates	.925	.671	.918	.815	.857	.756	.690
Soda in the insoluble silicates	.128	201	.312	.248	.260	.250	.234
Percentage of gravel, &c.	14.500	21.400	12.500	17 400	12.000	29.000	28.600
Character of the soil	Virgin soil	Virgin soil	Virgin soil	Old field	Subsoil.	Old field	Subsoil.

Of the above described soils of Rockcastle county, No. 2230, based on the coal-measure shales, &c., is quite a good soil; to be discounted, however, by its 14.5 per cent. of ferruginous sandstone fragments or gravel. No. 2231, situated on the Millstone grit, is the poorest of the whole, especially as it contains 21.4 per cent. of this gravel. The other soils described, all based on the Sub-carboniferous limestone formation, are better than the average of good soils; but are also to be discounted by their considerable percentage of sandstone gravel, of which the soil of the old field, No. 2235, and its subsoil, show much the largest proportions. In these old field soils may also be seen the usual results of long cultivation in the diminution of the alkalies, phosphoric acid, &c., as compared with the original virgin soil of the neighborhood. Such a comparison could not be accurately made unless the two soils were similarly located in relation to the action of the atmospheric waters; those on a slope being more subject to their deteriorating, washing influence than those on more level ground. This influence may probably be observed on the relative composition of soil No. 2232 situated on the slopes of Roundstone. The old field soil, No. 2233, is now quite rich.

TRIMBLE COUNTY.

No. 2237—"*A 'chalky substance' sent by Mr. S. E. Hampton for examination.*"

According to his report, it exists in a stratum about two feet

thick, discovered in digging a cistern about five feet below the surface, in a mound-like hill, the highest in the neighborhood, which is in Hunter's Bottom, about five miles below Carrollton.

It is a fine granular rock, soft enough to be scratched by the nail, nearly white, with a very faint yellowish tint. Under the microscope it was seen to be made up of minute, transparent crystals, in form somewhat like those of Aragonite. By tests it was found to be nearly pure carbonate of lime, with a trace of iron oxide.

If in large quantity, as it is said to be by Wm. Hampton, it might be utilized in the manufacture of soda ash from salt, or of glass, or it might be made valuable as an ingredient in the manufacture of Portland cement.

No. 2238—"*By the same person a sample of another white substance was sent, labeled 'Silicious clay,' forty feet thick and a mile wide, from near Milton, Trimble county.*"

Quite a friable concretion, which was found to be nearly pure quartz, with a minute quantity of carbonate of lime. The microscope shows it to be in the form of very minute, transparent, colorless, acicular, prismatic crystals.

This pure silicious deposit, which, like the preceding one of carbonate of lime, is doubtless of more recent deposit than rocky substratum, might be made profitable in the manufacture of glass, of pottery ware, of Portland cement, soluble glass, &c.

WAYNE COUNTY.

SOILS.

No. 2239—"*Virgin soil from the farm of Silas Hansford, in the northeast end of Wayne county, on the Dry Branch of Big Sinking creek, three miles due west from its mouth. This sample is from a piece of woods back of his house. Geological position: upper part of the Sub-carboniferous limestone, on a terrace which has received more or less of the débris from the sandstones and shales lying immediately above it.*" *Collected by Joseph Lesley, jr.*

The dried soil is friable, and of a light greyish-umber color. The coarse sieve separated from it 7.5 per cent. of fragments

of ferruginous sandstone, not much rounded. All of its silicious residue, from digestion in acids, passed through the bolting-cloth, except a small proportion of small, rounded, soft particles of partly-decomposed concretions, and of whitish and reddish quartz.

No. 2240—"*Surface soil from a field next adjoining to the location of the next preceding, which has been cleared two years. Last year it was in turnips; this year* (1859) *is in corn.*" *Collected by Joseph Lesley, jr.*

This dried soil resembles the preceding. The coarse sieve separated from it 4.4 per cent. of small, slightly-rounded ferruginous sandstone particles. Its silicious residue all passed through the bolting-cloth except a small proportion of small, rounded grains of white quartz, and of partly-decomposed concretions.

No. 2241—"*Subsoil of the next preceding,*" *&c., &c.*

The dried subsoil is rather lighter colored and more yellowish than the soil preceding. It contains some pretty firm clods. The coarse sieve separated from it 16.5 per cent. of irregular fragments, some pretty large, of ferruginous sandstone and concretions, some of which show much manganese oxide. The bolting-cloth removed from its silicious residue a smaller proportion of small grains of quartz, and of partly-decomposed concretions than from the preceding soils.

No. 2242—"*Virgin soil from farm of Silas Hansford, &c., &c. From below his house, in a dry, flat, swelling valley. Geological position: about the middle of the Sub-carboniferous limestone formation.*" *Collected by Joseph Lesley, jr.*

The dried soil is like No. 2239, slightly darker colored. It has some friable clods. The coarse sieve removed from it 6.6 per cent. of small, rounded, ferruginous silicious particles, and a few small quartz pebbles. From its silicious residue the bolting-cloth separated a little larger proportion of small, rounded friable particles of partly-decomposed concretions

than from the preceding soil; also a small proportion of small, rounded white quartz grains.

No. 2243—"*Surface soil from a field across the road from the location of the next preceding soil. This field has been in active cultivation for fifty years; mostly in corn; is this year* (1859) *in corn. No manure has been used.*" *Collected by Jos. Lesley, jr.*

The dried soil is like the preceding, very slightly darker colored and more brownish. The clods are a litttle more firm. The coarse sieve separated from it 11.2 per cent. of somewhat rounded, irregular ferro-silicious fragments or concretions. With the bolting-cloth its silicious residue gave similar results with the preceding.

No. 2244—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil is of a warm, brownish, dark-grey color. The clods are quite firm and more reddish in their interior than the powdered soil. The coarse sieve separated from it 10.3 per cent. of irregular, somewhat rounded, ferro-silicious fragments. From its silicious residue, after digestion in acids, the bolting-cloth removed quite a large proportion of small, rounded, friable particles of partly-decomposed concretions, and a few small, rounded grains of white quartz.

No. 2245—"*Virgin soil from the farm of John H. Phillips, Newberry Post-office, eleven miles southwest from Monticello, on the road to Albany, one mile west from Otter creek. Timber: white and black oak, hickory, dogwood. Geological position: Sub-carboniferous limestone. Soil: red ferruginous, on the great undulating plateau of Wayne and Clinton counties.*" *Collected by Joseph Lesley, jr., July,* 1859.

The dried soil is of a grey-brown or light snuff color; friable. The coarse sieve separated from it only 1.5 per cent. of small, rounded, ferruginous, silicious particles. Its silicious residue all passed through the bolting-cloth except very small proportions of small, rounded grains of partly-decomposed concretions and white quartz, with a few silicified portions of very small encrinital stems.

No. 2246—"*Surface soil from a field on the same level as the next preceding, cleared about sixty years ago, which was uninterruptedly in corn for the first twelve or twenty years. Of late years more attention has been paid to alternation of crops; but eight out of ten years of the sixty it has been in corn. Now* (1859) *in wheat stubble.*" *Collected by Jos. Lesley, jr.*

The dried soil is friable, and is of a handsome, light, reddish grey-brown color. The coarse sieve removed from it only 1.6 per cent. of small, rounded, ferruginous, silicious particles. Its silicious residue gave the same result with the bolting-cloth as the preceding.

No. 2247—"*Subsoil of the next preceding soil,*" *&c., &c.*

The dried subsoil resembles the soil next preceding, the color being only a light shade darker, being reddish grey-brown. The coarse sieve removed from it 3.2 per cent. of small, rounded, ferruginous, silicious particles and small quartz pebbles. With the bolting-cloth its silicious residue gave similar results with the two preceding soils.

No. 2248—"*Virgin soil from the farm of Hiram T. Hall, on the road from Albany to Monticello, six and three quarter miles southwest of the latter, and half way between Otter and Beaver creeks. Geological position: Sub-carboniferous limestone; red ferruginous horizon. Remarks: This specimen is taken from the so-called 'flat lands' of this county, which hereabout extend over a wide surface, and are estuary-like, being bays between long, low, wide noses which give the country a rolling character. Corn and other grains will not grow on it, although timothy and herd-grass are grown with great success. Timber: White and pin oaks, hickory and sugar maple.*" *Collected by Jos. Lesley, jr.*

The dried soil is friable and of a light ash-grey color. The coarse sieve separated from it only a very small proportion of shot iron ore. Its silicious residue all passed through the bolting-cloth, except very small proportions of small, friable,

rounded particles of partly-decomposed concretions and of white quartz.

No. 2249—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil is much lighter colored than the soil next preceding, being of quite a light, yellowish-grey tint. It has some friable clods. The coarse sieve removed from it only a very small proportion of shot iron ore and small, silicious concretions. The bolting-cloth separated from its silicious residue a considerable proportion of small, rounded particles of partly-decomposed concretions and a few of white and reddish quartz.

No. 2250—"*Virgin soil from the red ferruginous soil horizon, or the Sub-carboniferous limestone formation. From the farm of Hiram T. Hall. This soil is a fair average of the farming lands of this portion of Wayne county.*" *Collected by Joseph Lesley, jr.*

The dried soil is friable and of an umber color. The coarse sieve separated from it 5.8 per cent. of angular, cherty fragments. The bolting-cloth removed from its silicious residue only very small proportions of partly-decomposed concretions and quartz grains.

No. 2251—"*Surface soil from a field adjoining the location of the next preceding, which has been in cultivation every year for sixty years, the first twenty years in corn; now* (1859) *in wheat stubble; last year in corn, and the year before in wheat.*" *Collected by Joseph Lesley, jr.*

The dried soil is friable and of a handsome, reddish, light grey-brown color. The coarse sieve removed from it 1.9 per cent. of angular, cherty fragments, and some little shot iron ore. The bolting-cloth separated from its silicious residue a considerable proportion of small, rounded, friable particles of partly-decomposed concretions and a few of small, rounded, white quartz grains.

No. 2252—"*Subsoil of the next preceding*," *&c., &c.*

The dried subsoil is somewhat cloddy. It is of a handsome light-ferruginous or brick color. The coarse sieve separated from it but a very small proportion of small, cherty particles. The bolting-cloth removed from its silicious residue quite a large proportion of small, rounded grains of partly-decomposed concretions and only a few small, rounded grains of quartz.

No. 2253—"*Virgin soil from the ridge between Big Sinking creek and Elk Spring valley, on the property of Edward Morrow, near the water-shed at the road crossing, three quarters of a mile south of Alexander's coal bank, and five miles east from Monticello. Geological position: Coal-bearing sandstones and shales, seventy feet below the main coal.*" *Collected by Joseph Lesley, jr.*

The dried soil is light and friable and of a very light buff-grey color. The coarse sieve separated from it 33.4 per cent. of pretty large, angular fragments of ferruginous sandstone, mixed with some smaller, rounded ones. From its silicious residue the bolting-cloth removed very few small, rounded particles of partly-decomposed concretions and quartz.

No. 2254—"*Virgin soil from a ridge dividing Cedar Sinking creek from Dry valley, near Double-headed Gap, in the north-east portion of the county. Geological position: Coal-bearing sandstones and shales, seventy feet above the top of the Sub-carboniferous limestone.*" *Collected by Joseph Lesley, jr.*

Dried soil friable; of a purplish-grey color: ash-grey. The coarse sieve separated from it 21.2 per cent. of angular frag. ments of ferruginous sandstone. The bolting-cloth removed from its silicious residue only a small proportion of particles of partly-decomposed concretions and no quartz grains.

COMPOSITION OF THESE WAYNE COUNTY SOILS, DRIED AT 212° F.

	No. 2239	No. 2240	No. 2241	No. 2242	No. 2243	No. 2244	No 2245	No. 2246	No. 2247	No 2248	No 2249	No. 2250	No 2251	No. 2252	No. 2253	No 2254
Organic and volatile matters	5.865	4.985	2.675	4.435	4.710	3.350	4.696	5.310	3.015	4.710	2.300	7.640	3.275	2.925	1.850	5 920
Alumina and iron and manganese oxides	8.089	3 944	4.201	6.347	5.817	8.814	9.151	8.922	8.681	5.140	6.031	8.415	8.215	8.279	2 836	5.703
Lime carbonate	.270	.360	.195	.405	.345	.345	.130	.145	.195	.205	.120	.460	.195	.070	.195	.345
Magnesia	.124	.187	.102	.187	.142	.133	.112	.147	.106	.154	.122	.088	.151	.151	.073	.286
Phosphoric acid	.096	.076	.076	.061	.093	.061	.099	.118	.109	.115	.084	.125	.125	.061	.029	.087
Potash, extracted by acids	.217	.166	.282	.206	.201	.220	.260	.266	.192	.212	.170	.184	.126	.259	.021	.·49
Soda, extracted by acids	.061	. . . .	. . . .	. . . .	. . . .	.014	.059	.011	. . . .	. . . .	.035	.020	. . . .	.072	.050	.069
Water, expelled at 380° F.	1 850	1.200	1.025	1.265	1.265	1.050	2.440	1.565	1.300	2 090	735	3.650	1.240	.615	.500	1.715
Sand and insoluble silicates	83.290	88.990	91.865	87.490	87.130	85.740	83.115	84.265	86.465	87.015	90.615	79.315	86 415	86.990	94.590	85.690
Total	99.862	99.908	100.421	100.396	99.703	99.727	100.061	100.749	100.063	99.641	100.212	99.897	99.742	99.422	100.144	100.064
Hygroscopic moisture	2.025	1.435	0.900	1.560	1.500	1.650	2.335	1.510	1.525	1.560	1.185	3.150	1.475	1.625	0.440	1.565
Potash in the insoluble silicates	.931	.651	.566	.614	.762	.859	.784	.729	.772	.570	.531	1.012	.799	.878	.711	.984
Soda in the insoluble silicates	.279	.196	.168	.159	.199	.183	.284	.289	.199	.127	.227	.262	.199	.161	.152	.274
Percentage of gravel	7 500	4.400	16.500	6.600	11.200	10.300	1.500	1.600	3.200	sm p'n.	sm. p'n	5.800	1.900	sm. p'n.	33.400	21.200
Character of the soil	Virgin soil.	Cult iv'd field.	Subsoil.	Virgin soil	Old field soil.	Subsoil	Virgin soil.	Old field soil	Subsoil	Virgin soil.	Subsoil	Virgin soil.	Old field	Subsoil.	Virgin soil.	Virgin soil.

All of these soils, which are based on the Sub-carboniferous limestone formation, appear, from their chemical composition and physical condition, to be very good and fertile, requiring only good management to make them productive. This is especially the case with No. 2250, said by Mr. Lesley to be a fair average of the farming lands of the red ferruginous horizon, in Wayne county, which may be classed among our rich soils. No. 2248 is said not to produce corn or other grains, but to be favorable to the growth of timothy and other grasses. As no reason for this default appears in its analysis, it is probably due to imperfect local drainage.

In all these soils the subsoils seem to be less rich than the surface soils; so that, for the present at least, no other benefit would result from deep plowing except that of loosening the substratum for more perfect drainage, or the extension of the roots of growing crops.

Soils Nos. 2239, 2240, and 2241, especially the subsoil, show the presence of the débris of the sandstones and shales lying above them; and soil No. 2253, lying on the water-shed of a ridge on the coal-bearing sandstones and shales, which is the poorest of all these soils, shows in a marked manner the deteriorating effects of the wash of the atmospheric waters through it, especially in its large proportions of gravel, sand and insoluble silicates, and its small quantities of organic matters, potash, soda, phosphoric acid, alumina, &c. Soil No. 2254, from a similar geological position and also on a ridge, shows much less of the effects of this surface washing, probably because it may be more favorably located in relation to the drainage, and may be considered a soil of good average fertility, under good management, notwithstanding its 21.2 per cent. of small, rocky fragments of coarse gravel, which diminishes its value about one fifth.

WEBSTER COUNTY.

SOILS.

No. 2255—"*Virgin soil from the farm of Col. Scott, Sebree City, on the L. and S. E. Railroad. Timber: white and red oaks, dogwood, whitewood, black walnut,*" *&c. Collected by C. W. Beckham.*

The dried soil is of a brownish umber-grey or chocolate-grey color. The clods are friable. It all passed through the coarse sieve except a little vegetable débris. Its silicious residue (*i. e.*, sand and insoluble silicates) all passed through the bolting-cloth except a very few small silicious grains.

No. 2256—"*Surface soil from a field seventy-five years in cultivation in corn and tobacco. Same locality as that of the preceding soil, but on a hill fifteen feet above the flats.*" *Collected by C. W. Beckham.*

The dried soil is generally of a dull brownish yellow-ochre color, mottled with reddish in the clods, which are quite firm. It contains fragments of charcoal. It all passed through the coarse sieve except a few small fragments of friable sandstone. The bolting-cloth removed from its silicious residue but a small proportion of small, rounded grains of white quartz and of partly-decomposed concretions.

No. 2257—"*Subsoil of the next preceding,*" *&c., &c.*

The dried subsoil is of a brighter brownish yellow-ochre color than the preceding. Its clods are quite firm. It all passed through the coarse sieve. Its silicious residue gave the same results with the bolting-cloth as that of the preceding.

No. 2258—"*Surface soil from a field more than fifty years in cultivation. Tobacco and corn the principal crops. Farm of Mr. Kaufman, Slaughterville Station, L. and S. E. Railroad.*" *Collected by C. W. Beckham.*

The dried soil is quite friable and of a brownish yellowish dark-grey color. It all passed through the coarse sieve. Its

silicious residue gave the same results with the bolting-cloth as the preceding.

No. 2259—"*Subsoil of the next preceding; used for making bricks,*" *&c.*

The dried subsoil is in quite firm clods, of a browish yellow-ochre color. It all passed through the coarse sieve.

No. 2260—"*Surface soil from a field ten years in cultivation; principally in corn and tobacco. Farm of A. G. Brooks, Elmwood Station, L. and S. E. Railroad.*" *Collected by C. W. Beckham.*

The dried soil is of a brownish-drab or dirty-buff color. Its clods are friable. It all passed through the coarse sieve, leaving on it only some vegetable débris. With the bolting-cloth its silicious residue gave the same results as the preceding soils.

No. 2261—"*Subsoil of the next preceding,*" *&c., &c.*

The dried subsoil is of a brownish-buff color, brighter than that of the preceding. Its clods are quite firm, and mottled with lighter-buff and ochreous tints. It all passed through the coarse sieve except vegetable débris and a few small ferruginous concretions. Its silicious residue gave the same results with the bolting-cloth sieve as the preceding soils of this collection.

COMPOSITION OF THESE WEBSTER COUNTY SOILS, DRIED AT 212° F.

	No. 2255	No. 2256	No. 2257	No. 2258	No. 2259	No. 2260	No. 2261
Organic and volatile matters	3.975	5.035	3.365	2.610	2.440	3.450	2.210
Alumina & iron & manganese oxides.	4.225	8.480	11.383	4.665	7.661	3.986	5.639
Lime carbonate	.330	1.895	.220	.145	.120	.270	.145
Magnesia	.277	.436	.450	.160	.241	.184	not est.
Phosphoric acid	.140	.285	.157	.125	.054	.094	.061
Potash extracted by acids	.064	.313	.392	.124	.071	.126	.108
Soda extracted by acids	.323	.030	.040	.012	.016	.057	.439
Water expelled at 380° F.	.950	.900	.800	.565	.585	1.250	.775
Sand and insoluble silicates.	89.855	82.940	83.205	91.445	88.755	90.490	90.815
Total	100.139	100.314	100.012	99.851	99.943	99.907	100.192
Hygroscopic moisture	1.680	2.850	3.325	1.200	1.975	1.575	1.365
Potash in the insoluble silicates.	1.697	1.730	1.956	1.544	1.779	1.570	1.750
Soda in the insoluble silicates.	.672	.482	.563	.712	.690	.746	.366
Character of the soil	Virgin soil	Old field soil.	Subsoil.	Old field soil.	Subsoil.	Cultivated field.	Subsoil.

The soil of the old field, seventy-five years in cultivation in tobacco and corn, with its subsoil, Nos. 2256 and 2257, must have been naturally much richer than the virgin soil, No. 2255, of its neighborhood, if the labels accompanying the samples are correct; for, notwithstanding its prolonged use in the production of exhausting crops, it contains much larger proportions of the essential elements of fertility than that, and may yet be classed amongst the rich soils. Most of these described above are at least of average fertility, the only apparent deficiency being of available potash in Nos. 2255 and 2259, and of phosphoric acid in Nos. 2260 and 2261, and in subsoils 2259 and 2261—ingredients which can readily be supplied in appropriate fertilizers. These soils are all in a favorable physical condition, being friable and in a state of fine division, and containing no gravel.

TABLE I. SOILS, SUBSOILS, AND UNDER-CLAYS, DRIED AT 212° F.

Number.	County.	Organic and volatile matters.	Alumina and iron oxide, &c.	Lime carbonate	Magnesia.	Phosphoric acid	Potash.	Soda.	Water expelled at 380° F.	Sand and insoluble silicates.	Water expelled at 212° F.	Potash in the insoluble silicates.	Soda in the insoluble silicates.	Gravel.	Remarks.
2096	Ballard. . .	4.065	5 904	1.095	0.394	0.246	0.289	0.242	0.935	87.120	2.000	1.619	0.680	. . . .	Top soil Bar's, 4 yrs. in cult.; W. H. Reeves.
2097	Ballard. . .	2.790	7.597	.295	.308	.093	.449	.148	.760	87.395	2.300	1.482	.674	. . . .	Subsoil of the same.
2098	Ballard . .	2.185	8.557	.195	.544	.093	.131	.653	.450	87.110	2.735	1.085	.536	. . . .	S'bs'l or un'r-clay; uplands around Blandville.
2099	Ballard. . .	1.565	7.835	.645	.601	.140	.175	.309	.435	87.495	2.300	2.138	1.208	. . . .	Sub. or un'r clay, uplands sev'l ft. below surface
2100	Ballard. . .	3.210	6.150	.155	.268	.115	.203	.364	1.065	88.890	1.865	1.659	1.165	. . . .	Virgin soil; bottom land, Mayfield creek.
2101	Ballard. . .	2.565	3 864	.385	.163	.061	.319	.362	.635	92.010	1.075	1.358	.616	. . . .	Old field soil; bottom land, Mayfield creek.
2102	Ballard. . .	2.125	5.088	.245	.184	.077	.276	.129	.675	91.570	1.125	1.401	.911	. . . .	Subsoil of next preceding.
2109	Clinton. . .	6.615	5.984	.405	.232	.166	.212	not est.	1.400	84.990	1.585	.983	.217	22.40	Virgin soil; sub-car. limestone; Lewis Huff's.
2110	Clinton. . .	9.275	6.687	.620	.232	.173	.274	not est.	1.810	81.165	1.990	.998	.101	27.00	Cultiv'd soil; sub-car. limestone; Lewis Huff's.
2111	Clinton. . .	6.910	6 951	.480	.223	.259	.222	not est.	1.665	83.365	1.750	.972	.158	14.20	Subsoil of next preceding.
2112	Clinton. . .	3.000	2.932	.080	.106	.093	.155	not est.	1.550	92.240	.900	.327	.169	29.50	Virgin soil; sub-car. limestone; Jno. Wade's.
2113	Clinton. . .	4.320	6.129	.295	.124	.071	.170	not est.	1.940	86.790	1.800	.726	.263	4.40	Old field soil; sub-car. limestone; J. Wade's.
2114	Clinton. . .	4.695	6.247	.195	.108	.093	.188	not est	1.500	86.790	1.515	.621	.169	8.20	Subsoil of next preceding.
2115	Crittenden .	2.225	3 629	.160	.304	.086	.090	not est	.875	92.705	.890	1.876	.896	. . . .	Virgin soil; ridge; sandst'e; S. C. B. McMican.
2116	Crittenden .	2.950	8 718	.145	.350	.092	.309	.118	.925	86.665	.925	2.023	.750	. . . .	Subsoil of next preceding.
2117	Crittenden .	3.260	4.868	.270	.214	.067	.171	not est	1.225	89 440	1.565	1.707	.694	. . . .	Cultivated field, same locality.
2118	Crittenden .	2.885	8.173	.170	.703	.102	.122	not est.	.950	86.490	2.000	1.755	.588	. . . .	Subsoil of same field.
2123	Fulton . . .	9.305	10.437	1.385	.461	.198	.142	not est	3.110	74.840	4.100	1.889	.607	. . . .	Top soil; Mississippi bottom land.
2124	Fulton . . .	4.725	5.127	1.045	.234	.198	.321	.419	1.150	87.145	2.350	1.814	.858	. . . .	Cultivated soil; Mississippi bottom land.
2125	Fulton . . .	3.075	5.335	.360	.175	.055	.179	not est.	1.025	89 945	1.685	1.767	.828	. . . .	Virgin soil; Dr. G. W. Pascal's.
2126	Fulton . . .	2.300	4.974	.190	.162	.156	.290	.124	.775	91.745	1.400	1.664	.749	. . . .	Old field soil; Dr. G. W. Pascal's.
2127	Fulton . . .	2.535	8.690	.195	.331	.125	.141	.098	.900	86.895	2.585	1.892	.715	. . . .	Subsoil of the next preceding.
2128	Fulton . .	3.090	3.825	.395	.214	.125	.066	not est.	1.050	91.125	1.335	1.784	1.208	. . . .	Virgin soil; Capt. Henry Tyler's farm.
2129	Fulton . . .	2.285	7 700	.145	.268	.115	.186	.142	.840	87.795	2.610	1.675	.893	. . . .	Subsoil of next preceding soil; same farm.
2130	Fulton . . .	8.375	6.860	1.395	.598	.125	.332	.073	2.650	79.340	3.585	1.865	1.030	. . . .	Old field soil; Mississippi upland; same farm.
2131	Fulton . . .	4.140	10.560	.795	.169	.115	.208	.327	1.501	82.395	3.975	1.873	.841	. . . .	Subsoil of next preceding; same farm.
2132	Fulton . . .	2.860	3.560	.345	.142	.125	.074	.182	.975	91.740	1.000	1.969	.892	. . . .	Virgin soil; upland; same farm.
2133	Fulton . . .	2.165	6.550	.110	.232	.140	.275	.050	.650	89.670	1.725	1.935	.991	. . . .	Subsoil of next preceding.
2150	Henderson .	4.525	5.004	.570	.317	.131	.196	.112	1.225	87.990	1.815	1.654	.775	. . . .	Virgin soil; woodland pasture; W. Thompson's.
2151	Henderson .	3.150	3.968	.385	.241	.102	.238	.143	.865	91.315	1.200	1.619	.815	. . . .	Cultivated field; W. Thompson's.
2152	Henderson .	2.780	5.879	.520	.304	.061	.142	not est.	.735	89 215	1.900	2.036	.570	. . .	Subsoil of next preceding; W. Thompson's.
2153	Henderson .	2.125	5.979	.195	.245	.061	.236	not est.	.420	90.725	1.350	1.672	.763	. . . .	Old field soil; J. D. Robsard's.
2154	Henderson .	2.900	10.047	.130	.304	.093	1.097	not est.	.550	85.365	2.575	1.755	.608	. . . .	Subsoil of the same; J. D Robsard's.
2155	Henderson .	3.465	3.113	.120	.166	.077	.363	.165	.600	92.290	1.175	1.121	.742	. . .	Virgin soil; woods pasture; Mr. Klute.
2156	Henderson .	3.025	4.048	.195	.196	.067	.550	not est.	.600	91.625	1.325	1.127	.714	. . . .	Old field soil; Mr. Klute.
2157	Henderson .	3.290	9.589	.950	.342	.061	.429	.185	.580	85.040	1.850	1.128	.819	. . . .	Subsoil of next preceding; Mr Klute.
2158	Henderson .	3.835	3.364	.220	.175	.061	.371	not est.	.715	91.665	1.125	1.274	.846	. . . .	Virgin soil; woods pasture; S. H. Busbey's.
2159	Henderson .	2.785	4.129	.220	.309	.061	.382	.123	.566	91.840	1.025	1.457	.704	. . . .	Old field soil; S. H. Busbey's.
2160	Henderson .	3.350	9.644	.195	.195	.121	.357	.109	.675	85.890	2.100	1.573	.611	. . . .	Subsoil of the same; S. H. Busbey's.
2161	Hickman . .	4.140	3.694	.495	.232	.156	.182	.564	1.010	90.095	1.735	1.899	.573	. . . .	Upland soil, two years in cultivation.
2206	Madison . .	7.240	10 353	2 485	.989	.387	545	.162	1.122	76.715	3.275	1.949	.206	sm. p'n	Top soil, in cult. 26 yrs; on Cumberland shales.
2207	Madison . .	7.150	10.905	1.870	.809	.300	.638	not est.	1.450	77.395	3.775	2.079	.281	sm. p'n	Subsoil of same field.
2208	Madison . .	2.950	11.032	.220	.160	.173	.359	not est.	.800	84.174	2.575	1.800	.407	sm. p'n	Bottom clay, under the preceding.

TABLE I. SOILS, SUBSOILS, AND UNDER-CLAYS, DRIED AT 212° F.—Continued.

Number.	County.	Organic and volatile matters.	Alumina and iron oxide, &c.	Lime carbonate.	Magnesia.	Phosphoric acid.	Potash.	Soda.	Water expelled at 380° F.	Sand and insoluble silicates.	Water expelled at 212° F.	Potash in the insoluble silicates.	Soda in the insoluble silicates.	Gravel.	Remarks.
2212	McCracken	1.840	5.883	0.070	0.200	0.082	0.186	0.314	0.485	90.520	1.500	1.773	0.855	sm. p'n	Subsoil; land of Dr S. B. Caldwell.
2213	Nelson . .	3.360	7.977	.270	.166	.108	.116	.225	1.215	86.650	1.485	1.669	.274	1.400	Cul'd field, near Rohan's Knob; Mr. Ballard's
2214	Nelson . .	2.990	10.349	.245	.187	.061	.164	.045	.900	85.075	2.525	1.835	.400	.500	Subsoil of the same.
2215	Nelson . .	3.300	14.368	.880	.809	.102	.361	.657	2.415	76.840	1.129	2.742	.225	1.000	Under-clay of the same.
2217	Pulaski. . .	3.890	5.661	.125	.088	.089	.345	.027	.925	88.690	.915	.642	.205	31.600	Virgin soil on ridge; farm of Mr. Taylor.
2218	Pulaski. . .	4.200	5.640	.095	.070	.045	.222	. . . .	1.000	88.765	1.315	.927	.287	9.200	Virgin soil on ridge; coal-measures.
2219	Pulaski. . .	6.375	6.726	.345	.124	.059	.277	.139	1.425	84.350	1.900	.852	.139	19 200	Cultivated soil; same locality.
2220	Pulaski. . .	3.260	7.894	.095	.124	.076	.066	.256	.790	87.640	1.235	.878	.220	34.700	Subsoil of next preceding.
2221	Pulaski. . .	2.135	4.090	.170	.052	.045	.147	.071	.525	92.765	2.135	.778	.260	13.800	Virgin soil, on sub-carboniferous limestone.
2222	Pulaski. . .	2.550	5.109	.245	.097	.076	.151	.060	.650	91.240	.900	.967	.349	15.000	Old field, in same locality.
2223	Pulaski. . .	2.140	6 240	.170	.128	.045	.217	.083	.560	90.540	.965	1.047	.340	3.100	Subsoil of the next preceding.
2224	Pulaski. . .	2.225	7.767	.195	.213	.083	.351	. . . .	.595	88.790	.775	1.237	.289	4.500	Under-clay of next preceding.
2225	Pulaski. . .	4.590	4.938	.220	.115	.087	.145	.089	1.535	88.340	1.750	.953	.223	8.000	Virgin soil; sub-car. limestone; "Barrens."
2226	Pulaski. . .	5.615	7.072	.295	.146	.118	.100	.084	1.985	84.500	1.525	.863	.199	1.500	Old field soil; same locality.
2227	Pulaski. . .	3.790	7.847	.130	.122	.093	.213	n. e.	1.400	86.675	1.200	.762	.230	sm. p'n	Subsoil of the next preceding.
2228	Pulaski. . .	4.300	8.282	.310	.115	.148	.149	n. e.	1.700	84.990	1.225	.826	.167	sm. p'n	Old field soil; same locality.
2229	Pulaski. . .	3.700	8.923	.220	.115	.077	.149	n. e.	1.550	85.490	1.340	.795	.160	sm p'n	Subsoil of next preceding.
2230	Rockcastle .	6.890	7.126	.345	.223	.109	.366	.093	1.925	82.690	2.085	.925	.128	14.500	Virgin soil; coal-bearing sandstones and shales
2231	Rockcastle .	4.150	3.877	.085	.120	.083	.100	n. e.	.750	90.665	.900	.671	.201	21.400	Virgin soil; ridge; millstone grit.
2232	Rockcastle .	4.950	7.342	.435	.232	.093	.231	.008	1.300	85.065	1.775	.918	.312	12.500	Virgin soil; slopes of sub-car. limestone.
2233	Rockcastle .	6.065	8.565	.640	.153	.146	.339	n. e.	1.650	82.040	2.225	.815	.248	17.400	Old field soil; same locality.
2234	Rockcastle .	4.265	8.490	.625	.175	.220	.453	.125	1.375	83.890	1.915	.857	.260	12.000	Subsoil of the next preceding.
2235	Rockcastle .	4.500	7.097	.495	.130	.173	.208	.002	1.300	85.980	1.510	.756	.250	29.000	Old field soil; same locality.
2236	Rockcastle .	3.360	7.025	.395	.187	.125	.254	.031	.965	87.690	1.250	.690	.234	28.600	Subsoil of next preceding.
2239	Wayne . .	5.865	8.089	.270	.124	.096	.217	.061	1.850	83.290	2.025	.931	.279	7.500	Virgin soil; sub-car. limestone; upper part.
2240	Wayne . .	4.985	3.944	.360	.187	.076	.166	. . . .	1.200	88.990	1.435	.651	.196	4.400	Cultivated field soil; same locality.
2241	Wayne . .	2.675	4.201	.195	.102	.076	.282	. . . .	1.025	91.865	.900	.566	.168	16.500	Subsoil of next preceding.
2242	Wayne . .	4.435	6.347	.405	.187	.061	.206	. . . .	1.265	87.490	1.560	.614	.159	6.600	Virgin soil; sub-car. limestone; middle part.
2243	Wayne . .	4.710	5.817	.345	.142	.093	.201	. . . .	1.265	87.130	1.500	.762	.199	11.200	Old field soil; same locality.
2244	Wayne . .	3.350	8.814	.345	.133	.061	.220	.014	1.050	85.740	1.650	.859	.183	10.300	Subsoil of next preceding.
2245	Wayne . .	4.695	9.151	.130	.112	.099	.260	.059	2.440	83.115	2.335	.784	.284	1.500	Virgin soil; sub-car. limestone; ferrug. horizon
2246	Wayne . .	5.310	8.922	.145	.147	.118	.266	.011	1.565	84.265	1.510	.729	.289	1.600	Old field soil; same locality.
2247	Wayne . .	3.015	8.681	.195	.106	.109	.192	. . . .	1.300	86.465	1.525	.772	.199	3.200	Subsoil of next preceding.
2248	Wayne . .	4.710	5.140	.205	.154	.115	.212	. . . .	2.090	87.015	1 560	.570	.127	sm. p'n	Virgin soil; sub-car. limestone red fer. horizon
2249	Wayne . .	2.300	6.031	.120	.122	.084	.170	.035	.735	90.615	1.185	.531	.227	sm. p'n	Subsoil of next preceding.
2250	Wayne . .	7.640	8.415	.460	.088	.125	.184	.020	3.650	79.315	3.150	1.012	.262	5.800	Virgin soil; same formation.
2251	Wayne . .	3.275	8.215	.195	.151	.125	.126	. . . .	1 240	86.415	1.475	.799	.199	1.900	Old field soil; same formation.
2252	Wayne . .	2.925	8.279	.070	.151	.061	.259	.072	.615	86.990	1.625	.878	.161	sm. p'n	Subsoil of next preceding.
2253	Wayne . .	1.850	2.836	.195	.073	.029	.021	.050	.500	94.590	.440	.711	.152	33.400	Virgin soil; ridge; coal-bearing sandst & shales
2254	Wayne . .	5.920	5.703	.345	.286	.087	.249	.069	1.715	85.690	1.565	.984	.274	21.200	Virgin soil; ridge; coal-bearing sandst & shales.
2255	Webster . .	3.975	4.225	.330	.277	.140	.004	.323	.950	89.855	1.680	1.697	.672	. . . .	Virgin soil; farm of Col. Scott.
2256	Webster . .	5.035	8.480	1.895	.436	.285	.313	.030	.900	82.940	2.850	1.730	.482	. . . .	Old field soil; same locality.

2257	Webster . .	3.365	11.383	.220	.450	.157	.392	.040	.800	83.205	3.325	1.956	.563	. . . . Subsoil of next preceding.
2258	Webster . .	2.610	4.665	.145	.160	.125	.124	.012	.565	91.445	1.200	1.544	.712	. . . . Old field soil; farm of Mr. Kaufman.
2259	Webster . .	2.440	7.661	.120	.240	.054	.071	.016	.585	88.755	1.975	1.779	.690	. . . . Subsoil of next preceding.
2260	Webster . .	3.450	3.986	.270	.184	.094	.126	.057	1.250	90.490	1.575	1.570	.746	. . . . Field 10 yrs. in cultv'n; farm of A. G. Brooks.
2261	Webster . .	2.210	5.639	.145	n. e.	.061	.108	.439	.775	90.815	1.365	1.750	.366	. . . . Subsoil of next preceding.

TABLE II. CLAYS, DRIED AT 212° F.

Number.	County, &c.	Silica.	Alumina.	Iron oxide.	Lime.	Magnesia.	Potash.	Soda.	Water and loss.	Fine sand.	Remarks.
2104	Ballard. . .	74.460	18.070	1.633	0.314	0.245	0.940	0.021	4.317	48.00	Near Moore's mill, near Blandville; four feet thick.
H	Germany .	70.860	20.900	1.560	.347	.220	.578	.112	6.800	4.00	German glass-pot clay.
I	Germany .	73.660	19.460	1.560	.168	.209	.520	.046	6.200	3.50	German glass-pot clay.
2105	Ballard. . .	67.501	23.051	2.109	.257	.065	.412	.020	6.585	n. e.	South Ballard county; T. D. Campbell's.
2134	Fulton . . .	64.800	21.070	5.270	1.400	.050	.646	.202	6.562	"	Hickman bluffs; indurated clay.
2135	Fulton . . .	76.860	14.600	3.020	.425	.308	.736	.257	3.794	"	Hickman bluffs; ninety-five feet above low water.
2136	Fulton . . .	83.380	9.800	2.120	.963	.187	.617	.118	2.815	"	Hickman bluffs; first beneath gravel.
2137	Fulton . . .	71.340	17.190	2.770	1.612	.209	.925	.232	5.722	"	Hickman bluffs; first beneath gravel.
2138	Fulton . . .	83.500	9.940	2.500	.358	.173	.539	.109	2.881	"	Hickman bluffs; ten feet below the gravel
2139	Fulton . . .	71.080	19.050	2.810	.627	.403	.578	.225	5.227	"	Hickman bluffs; above the next preceding.
2140	Fulton . . .	74.100	16.460	2.700	.358	.187	.559	.135	5.501	"	Hickman bluffs; below the preceding
2141	Fulton . . .	77.960	13.970	2.390	.134	.163	.797	.124	4.462	"	Hickman bluffs; above the railroad track.
2142	Fulton . . .	68.860	12.980	2.240	9.587	1.182	1.773	1.278	2.100	"	Loess or "Bluff:" Quaternary.
2143	Graves . . .	75.550	16.751	1.198	a trace	.144	1.094	.216	5.047	63.00	On Panther creek; W. P. Arnett's land.
2161	Hickman. .	76.360	14.951	2.109	.325	.173	1.171	.125	4.786	69.00	From Chalk bluff, below Columbus.
2162	Hickman. .	84.918	10.560	1.102	.572	.108	.651	n. e.	2.089	68.50	From bluffs, upper part of Columbus.
2168	Madison .	62.560	24.780	1.800	a trace	.317	3.276	.294	6.973	n. e.	Near Bybertown; M. Barlow's.
2169	Madison . .	64.566	20.160	4.200	.213	.641	5.054	n. e.	5.166	"	Near Waco; below Corniferous limestone.
2170	Madison . .	62.580	22.940	3.760	.560	.425	5.280	.308	4.147	"	Indurated clay, near Elliston; Corniferous limestone.
2211	McCracken.	64.480	24.691	1.869	.448	.137	1.457	.083	6.835	"	Near Paducah.

TABLE III. MARLY CLAYS AND SHALES, DRIED AT 212° F.

Number.	County.	Silica.	Alumina.	Iron Peroxide.	Lime.	Magnesia.	Phosphoric acid.	Potash.	Soda.	Water, &c., and loss	Remarks.
2120	Fayette	53.780	23.260	1.300	4.866	0.568	0.191	7.612	0.550	7.873	In Lower Silurian limestone strata.
2165	Jefferson	47.960	21.340	6.600	5.825	3.524	n. e.	5.265	.250	9.238	In limestone layers of Cincinnati Group.
2166	Jefferson	58.840	19.940	6.000	3.226	.857	"	4.490	.685	5.962	In limestone layers of Keokuk Group.
2167	Jefferson	61.900	18.520	6.220	.123	1.259	"	4.867	.612	6.499	In limestone layers of Keokuk Group.
2186	Madison	42.300	20.840	4.120	13.320	.461	"	2.387	.351	16.221	In Niagara Group, on Drowny creek.
2187	Madison	48.780	17.320	3.240	*19.285	.496	"	4.768	.240	5.871	Beneath Corniferous limestone; bed six feet or more.
2216	Nelson	61.100	18.200	6.000	4.904	1.542	"	4.101	.821	3.332	At the base of the Corniferous; many feet thick.

* Lime sulphate; gypsum or plaster of Paris.

TABLE IV. COALS, &c., AIR DRIED.

Number.	County.	Specific gravity.	Hygroscopic moisture.	Volatile combustible matters.	Coke.	Total volatile matters.	Fixed carbon in the coke.	Ash.	Character of the coke.	Color of the ash.	Percentage of sulphur.	Remarks.
2144	Graves	n. e.	4.13	16.22	79.65	20.35	10.25	69.40	Pulverulent . . .	Nearly white . .	n. e.	Bitum. shale; "brown coal;" Panther creek.
2145	Greenup	1.319	5.00	39.00	56.00	44.00	49.88	6.12	Spongy	Lilac-grey	1.986	Splint coal (No. 3): Fulton Coal Co.; stock.
2146	Greenup	1.286	2.00	47.36	50.64	49.36	38.24	12.40	Slightly coherent.	Grey-buff	1.554	Can. c'l (No. 4); Ind'n Run; Ful. C'l Co.; st'k
2147	Greenup	1.331	4.80	36.90	58.30	41.70	51.20	7.10	Dense	Lilac-grey	3.977	Coal (No. 4); Chinn's branch; Ful. C'l Co.; st'k
2148	Greenup	1.324	6.00	33.48	60.52	39.48	56.14	4.38	Dense	Lilac grey . . .	2.330	Coal (No. 7); Coalton coal; Ful. C'l Co.; stock

TABLE V. IRON ORES, DRIED AT 212° F.

Number.	County.	Iron peroxide	Alumina & phosphoric acid.	Lime carbonate.	Magnesia carbonate.	Water, alkalies, &c., and loss	Bituminous matter, water, and loss.	Silicious residue.	Percentage of iron.	Remarks.
2149	Harrison	21.200	12.870	1.290	6.621	8.329	. . . .	49.690	14.840	Thomas Hinkston's iron ore.
2201	Madison	28.440	5.240	.190	1.279	8.631	. . . .	56.220	18.890	Bog ore on the black shale formation.
2202	Madison	19.800	9.880	.380	1.844	5.806	. . . .	62.290	13.860	Bog ore on the black shale formation.
2203	Madison	30.870	11.560	.290	.897	6.403	. . . .	49.980	21.570	Bog ore on the black shale formation.
2204	Madison	17.300	14.820	.130	1.041	10.449	. . . .	56.260	12.110	Bog ore on the Cornliferous formation.
2205	Madison	19.500	16 360	trace.	trace	. . . .	24.200	39.940	13.650	Black band ore; on top of the coal; Comb's knob.

TABLE VI. LIMESTONES, DRIED AT 212° F.

Number.	County.	Lime carbonate.	Magnesiacarbonate.	Alumina.	Iron oxide.	Phosphoric acid.	Potash.	Soda.	Silicious residue.	Percentage of lime.	Percentage of magnesia.	Silica.	Water, bitumen, &c., and loss.	Remarks.
2121	Franklin	70.360	6.784	5.458	1.342	n. e.	1.118	0.281	. . . .	39.401	3.236	14.020	. . . .	Kentucky river bluffs; Trenton Group
2189	Madison	48.530	11.790		10.330		1.696	.347	20.740	27.173	5.614	n. e.	6.567	Top of Cincinnati Group.
2190	Madison	37.760	10.050	17.656	3.700	0.204	.458	.090	25.180	21.145	4.785	20.980	4 902	On the top of Cumberland shales.
2191	Madison	33.560	6.855	21.560	4.120	.204	.578	.045	29.180	18.794	3.251	22.800	4.302	On the top of Cumberland shales.
2192	Madison	45.700	27.475	11.360	3.500	. . . .	.501	.088	9 980	25.592	13.083	n. e.	1.396	On the top of Cumberland shales.
2193	Madison	50.860	20.100	9.960	3.900	. . . .	.276	.054	3.980	28.480	9.608	n e.	10.870	Upper Silurian.
2194	Madison	50.960	27.972	5.960	*3.556	. . . .	.276	.087	4.120	28.538	13.319	n. e.	6.493	Upper Silurian.
2195	Madison	51.200	25.124	12.360	4.460	.140	.287	.049	3.920	28.672	11.899	n. e.	2.460	Upper Silurian.
2196	Madison	35.160	4.646	10.706	2.060	.754	2.033	.586	39.780	19.689	2.212	n. e.	4.275	Clinton Group.
2197	Madison	43.060	9.994	9.420	2.640	. . . .	.770	.149	22.680	24.113	4.756	n. e.	11.287	From Canda-Galli grit.
2198	Madison	41.150	13.908	9.040	1.890	. . . .	n. e.	n. e.	20.990	23.044	6.384	n e.	n. e.	From above Corniferous limestone.
2199	Madison	36.580	18.542	4.010	1.540	. . . .	n. e.	n. e.	31.990	20.485	8.781	n. e.	n. e.	Top of Cornlferous limestone.
2200	Madison	47.580	17.133		10.980	. . . .	n e.	n. e.	18.190	26.645	8.158	n. e.	6.117	Top of Corniferous limestone.
d 521	Jefferson	50.430	18.670		2.930	.060a	.320	.130	25.780	28.290	8.890	22.580	.100	Hydraulic; Falls of Ohio.
e 1068	Indiana	45.880	22.911	5.760		.220b	.347	.372	21.520	25.746	10.914	(c)	2.721	Hydraulic; Madison, Indiana.

(d). From Vol. II, first series Ky. Geol. Rep., p. 220, for comparison. (e) From Vol. IV, first ser. Ky Geol. Rep., p. 101, for comparison. * Iron sulphide 0.576 in addition.
(a). Sulphuric acid, 1.580. (b). Sulphuric acid, 0.269. (c). Silica soluble in solution of carb. soda=3.000.

GEOLOGICAL SURVEY OF KENTUCKY.

JOHN R. PROCTER, DIRECTOR.

COMPARATIVE VIEWS OF THE COMPOSITION

OF THE

SOILS, LIMESTONES, CLAYS, MARLS, &C., &C.,

OF THE

SEVERAL GEOLOGICAL FORMATIONS

OF KENTUCKY,

AS SHOWN BY THE CHEMICAL ANALYSES PUBLISHED IN THE SEVERAL

REPORTS OF THE GEOLOGICAL SURVEY OF THE STATE,

WITH REMARKS ON THEIR CHARACTERS AND PRACTICAL USES.

BY ROBERT PETER, M. D.,

CHEMIST TO KENTUCKY GEOLOGICAL SURVEY, STATE CHEMIST, PROFESSOR OF PHYSICS AND CHEMISTRY IN KENTUCKY STATE COLLEGE, &C. &C.

1883.

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INTRODUCTORY LETTER.

LABORATORY OF KENTUCKY GEOLOGICAL SURVEY
AND OF KENTUCKY STATE COLLEGE,
LEXINGTON, KY., April, 1883.

MR. JOHN R. PROCTER,

Director of Kentucky Geological Survey, &c.,

DEAR SIR: I herewith send you such comparative views of the composition of the Soils, Limestones, Clays, Marls. &c., of Kentucky as I have been able to obtain from the various characteristic specimens which have been analyzed in this laboratory during the progress of our Geological Survey, from its commencement in 1854, under the late Dr. D. D. Owen, down to the time of the latest published report of the work of the Survey.

Yours, respectfully,
ROB'T PETER.

A COMPARATIVE VIEW OF THE SOILS ON THE VARIOUS GEOLOGICAL FORMATIONS OF KENTUCKY.

In the study of Kentucky soils, and the numerous chemical analyses which have been made of them during the progress of the Geological Survey of the State, some facts of interest have been ascertained.

That all soils have been primarily produced by the disintegration of rock strata is now universally admitted. But, as the débris of rocks is continually transported, by water and other agencies, from higher to lower levels, and as, during the so-called glacial epochs of geological history, the bodies of ice, which covered a great portion of our northern hemisphere, caused the transfer of an immense amount of these soil materials, few localities present any large area of soil which has been formed where it is at present found by the decomposition of the rock strata in place.

Kentucky is quite exceptional in this respect, as compared with the extensive regions to the north and west of our State. The valley of the Ohio river seems to have been the limit beyond which could not be carried the great mass of mixed materials—clay, sand, gravel, and bowlders of all sizes—derived generally from rocks in place in the far Northwest, which cover the surface on this whole vast territory, so that the superficial deposit which constitutes the soil generally bears no relationship to the rock strata beneath.

Most of the soils of Kentucky have been formed from the rock strata of their immediate vicinity, being what are termed *sedentary soils*, and hence generally show a relationship in composition to the geological formations on which they rest, except such of them found in the valleys and low grounds of the rivers and streams, made up of more recently transported materials, which come under the name of *alluvial soils*.

Kentucky is somewhat peculiar in another important circumstance. The superficial rocks from which her soils were produced seem, with very few exceptions, as in the case of the coarse sandstones and conglomerate rocks of our coal-measure strata, to have been primarily deposited and formed under the waters of a primeval ocean, at such a distance from the shores, and under such circumstances, as that none but earthy or sandy materials in the finest state of division, entered into their composition, and large relative proportions of lime, magnesia, clay, phosphates, &c., are found in them. Pebbles, gravel, coarse sand, or fragments of rock are rarely present, except in some of the soils of the coal-measures. In most cases, in the large number of soils analyses which have been made of Kentucky soils during the progress of the Geological Survey, the dry earth passed wholly through a sieve having sixty-four meshes to the centimeter square; and, after this fine earth had been submitted to the solvent action of acids, the remaining "sand and insoluble silicates" were fine enough to pass through a fine sieve having about 1,600 meshes to the centimeter square—finer than ordinary bolting-cloth. Indeed, this silicious residue of our best soils is so fine that it is not generally recognized as sand, and although it is readily permeated by water, it presents some of the adhesive and absorptive properties of clay. Sand, so-called, is not to be found in the beds of the local streams where this soil prevails, and building sand must be imported.

MANY CONDITIONS MUST CONCUR TO GIVE FERTILITY TO SOILS.

1. *Meteorological.*—The climate, as to temperature, amount of rain-fall, &c., &c., presents important conditions essential to fertility.

2. *Location.*—Land at the bottom of a slope receives the washings and finer, richer materials from the uplands. It is well known that the atmospheric and soil waters, passing through continually, carry these fertilizing materials to the lower levels. The upper slopes are thus continually leached and impoverished, while, as is sometimes observed in our own

State, the soil on the high level summits of hills is richer than that of the inclined valleys which drain their flanks.

3. *Drainage.*—No soil sodden with water can be productive of crops, however rich it may be in the elements of fertility. Kentucky is peculiarly fortunate in the fact that the great body of her soils are naturally drained. This is especially the case in the so-called "Blue Grass" soil, which, on somewhat elevated table-land, is underlaid by limestone containing numerous crevices and caverns, which carry off the surplus water. But in some few localities, especially where the black slate formation prevails, the disintegration of which produces a tough clay very retentive of water, the injurious effects of too much water are evident. The soil may be found to be quite rich in the elements of plant food, but is not correspondingly productive for want of drainage.

No better example of this can be given than that of a soil in Wayne county, based on the Sub-carboniferous Limestone formation, collected by the late Dr. Owen, and analyzed by the present writer in 1856 (see Rept. Ky. Geol. Surv., O. S., vol. 2, p. 273), which has the chemical composition of quite a rich soil, and is almost black because of its more than 21 per cent. of organic and volatile matters, but which was unproductive for "want of draining and access of air"—in the language of Dr. Owen, who added that with the aid of lime and a proper system of drainage, "I venture to predict it will become one of the most productive soils in the State."

Extensive experience in England, and in the older settled regions of this country, has demonstrated the great utility of underdraining the soil. Without attempting to describe the best methods of underdraining land, we will briefly state some of its benefits: 1. In allowing the excess of water to escape continually, it not only removes this one cause of sterility, but tends to increase the porosity of the soil and the area through which the roots of plants may spread and obtain nourishment. 2. Because the body of the soil, during the growing season, is constantly colder than the superincumbent atmosphere, a current of cold air is continually flowing out of

the open mouths of the drain pipes, which is supplied by warmer air from above. This continued slow circulation of air through the cool soil not only causes the drained soil to become earlier warmed in the spring than the undrained soil, but brings to the growing vegetation a constant supply of the gases and vapors of the atmosphere which are essential to plant growth. The warm air, full of vapor of water, also deposits in the soil a considerable amount of water, which is condensed on passing through the colder soil; so that the underdrained soil does not suffer so much from droughts as the undrained. 3. The abundant supply of air also favors those chemical changes of decomposition and recomposition by which the elements of fertility are brought into an available condition for the nourishment of plants.

4. *Physical conditions.*—The soil, to be fertile, must be in a state of fine division; coarse sand, gravel, or fragments of rock give little or no plant nourishment, and are usually excluded, by all agricultural chemists, from their estimate of the value of a soil. The "fine earth" only is taken into account or analyzed. Thus, in the annexed table of soil averages, the conglomerate soils, which contain an average of 20.7 per cent. of gravel or pebbles, must have their estimated value (based on the analyses of their "fine earth") discounted in this proportion. So, in the comparison of our rich "Blue Grass" soil with the very rich volcanic soil of Auvergne (see tables), a discount of 16 per cent. must be made from the latter for the same reason.

Moreover, as a large proportion of the food of plants is derived from the atmosphere directly or indirectly, no soil, however rich it may be, can be very productive unless it is in a porous condition. On this fact, fully demonstrated by long experience, are based many of the practices of the husbandman in stirring, loosening, and cultivating the soil, especially during the growing season.

5. *Chemical conditions.*—Soils, to be fertile, must contain clay and fine sand, mixed in such proportions as that, while readily permeable by water, they may yet be, to a certain degree,

adhesive. Pure sand and pure clay do not offer favorable conditions for vegetable growth; such a mixture of them as forms what is called a loam soil is generally considered the best. Fertile soils must also contain a certain proportion of organic matters, known generally by the name of *humus*, a mixture of substances derived from the decay of vegetable and animal matters, which gives the dark color to the soil as compared with the subsoil and the almost black hue to the rich garden mould. Humus makes the soil more light and porous, and possesses the power of absorbing the gases and vapors of the atmosphere, water, and dissolved natural fertilizers in a higher degree than any other ingredient of the soil. Undergoing a gradual oxidation, it furnishes carbonic acid, nitrogen compounds, and water, and by the ozone it forms during this process, favors the production of nitrogen compounds from the atmospheric elements. It holds ammonia, potash, phosphates, &c., against the leaching action of the atmospheric waters, yielding them readily to the rootlets of plants, and, by the acids it produces, in its ulterior state of decomposition, it aids in dissolving the essential mineral elements of the soil, making them available for plant food.

It has been the fashion, in recent times, to underrate the value of humus in the soil, blindly following the teachings of Liebig, who gave too exclusive importance to the mineral elements of fertility; but practical experience is corroborated by scientific investigation in giving a high value to humus as an ingredient of a fertile soil. "The latest conclusions of agricultural chemists are, that the excess of nitrogen in the crop over that contained in the soil is caused by the action, on the atmospheric elements, of the carbonaceous matters of the soil" (the humus).—Quoted from article "TERRES ARABLES" in *Wurtz's Dictionnaire de Chemie, &c.*

In this connection we are tempted to quote from a recent publication of Peter Henderson, of New York, one of the most experienced and enlightened gardeners in the country, the results of his observations and practical experiments. After stating that the concentrated commercial fertilizers "will not

do" for any great length of time to maintain fertility without the aid of stable manure, or some other means of improving what he terms the "physical condition of the soil," he states: "hence experienced market gardeners near New York rotate their fields." Of twenty acres they keep five in grain, clover, and grass, "to be broken up successively every second or third year, so as to get the land in the condition that nothing else but rotted, pulverized sod will accomplish." (*Humus.*) "This is done where the land is worth five hundred dollars per acre. Experience having proved that with one quarter of the land resting under grass more profit can be got than if the whole were under culture." And this in the region where they habitually apply several hundred dollars' worth of commercial fertilizers to the acre per annum.

In our newer country, where land is cheap, too little attention is paid to fallow and rotation of crops, which both may serve to renew the humus which has been removed in the cultivation of the hoed crops. Fallow, or allowing the land to rest, need not be a "*naked fallow*," or letting it rest with no other crop but weeds, but could more profitably be a "*green fallow*," combined with rotation when clover or grass are cultivated, to be fed to stock, and subsequently plowed under to increase the amount of humus and otherwise improve the soil. And when small grain of any kind is raised in the rotation, the straw, instead of being burnt up out of the way of the farmer, could be more profitably used on the English plan, in a so-called straw-yard, where it is fed to stock and trampled into valuable manure, to be hauled to the fields in the early spring.

It is now a well-established fact that cultivated soils require constant renewal of their elements of fertility, especially when the crops are habitually removed, and no return of manures are made to the soil. How most economically to effect this renewal is a practical question with most farmers, and one of great interest to the agricultural chemist.

Besides the humus and certain other atmospheric elements above mentioned, certain other ingredients, called the mineral

elements of fertility, are equally indispensable to the fertility of the soil and to vegetable growth. These are phosphoric acid, potash, lime, magnesia, sulphur, chlorine, iron, and others, in such a state of combination as to be available for plant nourishment.

Of these, all are alike essential as necessary elements in the composition of the vegetable. Yet, as some of them are found in very small proportions in soils, and are habitually carried off in the crops, such as the phosphoric acid and potash, the practical agriculturist holds these as the most essential, knowing that the other essential elements of the soil are usually present in it in inexhaustible quantities, or are continuously supplied from the atmosphere. Hence the value of a commercial fertilizer, in renovating an exhausted soil, depends mainly on its relative quantities of available phosphoric acid, of potash, and of nitrogen compounds, especially, also, because these ingredients only will bear the cost of transportation to any great distance, and the others are frequently to be found near the farm.

The farmer who consumes most of his products at home has usually little need of any fertilizers but those which are furnished by his stables, compost heaps, or cess-pools, properly utilized; or by a judicious rotation of crops and feeding of his stock on his fields. But the commercial farmer, whether he cultivates that most exhausting and damaging crop, tobacco, or annually exports his cotton, hemp, potatoes, corn, or other grain, or simply sells his live stock raised on the farm, correspondingly robs his soil of its essential elements of fertility, and, especially if he does not rotate his crops, must resort to commercial fertilizers to maintain its productiveness. The nature and quantity of these will depend on the composition of his soil and the character of his products sold off the farm; but available phosphates, compounds of potash, and nitrogen compounds are their most valuable ingredients. Marls, when near at hand, may be advantageously employed, in quantity, to modify the physical character of soils, and to supply lime when deficient, and potash and phosphates in some cases.

Lime, ground or burnt and slacked, proves useful also on some soils, especially when, like the blue limestone, it contains notable proportions of phosphates, potash, &c.; but both of these will not bear long transportation.

Although the clay and the sand of the soil are not actually elements of plant food, yet they, in proper mixture, are essential in furnishing the medium in and by which they obtain nourishment and growth, while the iron oxide which enters into the composition of the vegetable is almost always present in superabundance in the soil. The oxide of iron aids essentially in facilitating decomposition of organic matters, in the formation of fertilizing nitrogen compounds and by its great absorptive power. It is doubted by most agricultural chemists whether silica (the material of sand) is an essential article of plant food; yet it is present in notable quantity in all plants, especially in those of the family of grasses, and in the form of sand is necessary to the porous structure of soil.

What is the Chemical Composition of a Fertile Soil?

This question may be answered by reference to the appended Tables. (*See Summary of the Averages of the Kentucky Soils from Different Geological Formations, &c.*) The composition represented by the mean of the averages of the 234 Kentucky soils which were taken for comparison, represents, no doubt, that of soil of *rather more than average fertility.*

According to Mr. P. De Gasparin (a well known French authority):

0.20 per cent. of phosphoric acid in a soil makes it	*very rich.*
0.10 per cent. and upwards makes it	*rich.*
0.05 per cent. makes it	*poor.*
Between 0.1 and 0.05 per cent. makes it	*medium.*

Schlœssing's *average* of phosphoric acid in soils is 0.17 per cent. The richest volcanic soils contain 0.60 per cent., and the poorest soils quoted by Gasparin had only 0.09 or less per cent.

The proportions of potash, in relation to fertility, vary in nearly the same manner. Mr. P. De Gasparin, in his "*Traite*

des Terres Arables," gives the proportion of 0.14 per cent. of potash as a normal average quantity, and quotes, in the case of the volcanic soil of the vineyard of Lacryma-Christi, on the flanks of Vesuvius, the enormous percentage of 3.47 of potash in the fine earth. This, however, is to be discounted by 34. per cent. for pebbles present in this soil. Our richest Blue Grass soil or subsoil sometimes contains more than 0.70 per cent. in the virgin soil, and upwards of 1.00 per cent. in the subsoil or under-clay, and has no pebbles. The poorest Kentucky soil analyzed contains only 0.021 per cent. of *potash.*

By reference to the appended tables of the relative composition of the richest and poorest soils of Kentucky, and the examples of foreign soils which "are very fertile," the significance of the other tables of the composition of the soils on the several geological formations of Kentucky may be readily appreciated:

TABLE A.

AVERAGE COMPOSITION OF THE SOILS ON THE SEVERAL GEOLOGICAL FORMATIONS OF KENTUCKY.

	Organic and volatile matters.	Alumina and iron and manganese oxides.	Lime carbonate.	Magnesia.	Phosphoric acid (P_2O_5).	Potash, extracted by acids.	Sand and insoluble silicates.	Water expelled at 212° F.	Potash in the insoluble silicates.	Rock fragments, gravel, pebbles or sand.
(1.) ALLUVIAL SOILS.										
Lewis Co. (Ohio R. Valley). Vol. IV, N. S., pp. 105-6—average of 3 soils	3.472	9.835	0.102	0.189	0.118	0.450	84.310	2.513	1.405	0
Fulton Co. (Mississippi R. Valley). Vol. V, N. S., p. 424—average of 2 soils	9.305	10.437	1.385	.461	.198	.142	74.840	4.100	1.889	0
(2.) QUATERNARY (LOESS) SOILS.										
Ballard Co. Vol. V, N. S., p. 409—average of 7 soils and subsoils	2.673	5.713	.431	.351	.112	.263	88.798	1.871	1.535	0
Fulton Co. Vol. V, N. S., p. 425—average of 9 soils and subsoils	3.410	6.450	.437	.143	.120	.193	87.850	2.132	1.911	0
McCracken Co. Vol. V, N. S., p. 222—average of 5 soils and subsoils	2.458	9.543	.165	.479	.086	.365	87.765	3.083	1.577	0
Average of the 21 Quaternary soils	2.937	6.941	.370	.292	.118	.257	88.098	2.271	1.706	0
(3.) COAL-MEASURES SOILS.										
In the Old Series of Ky. Geol. Repts.—average of 40 soils and subsoils	4.234	5.821	.221	tr.	.134	.221	87.774	n. e.	n. e.	n. e.
Carter Co. Vol. I, N. S., p. 195—average of 4 soils and subsoils	3.067	5.038	.111	.050	.149	.210	90.567	1.285	. . . .	2.200
Daviess Co. Vol. IV, N. S., p. 57—average of 6 soils and subsoils	3.823	7.861	.140	.082	.100	.263	86.531	1.989	. . . .	n. e.

Hopkins Co. Vol. IV, N. S., p. 89 –average of 9 soils and subsoils	4.172	6.966	.223	.127	.076	.323	87.422	1.639	1.306	n. e.
Rockcastle Co. Vol. V, N. S., p. 468—1 soil	6.890	7.126	.345	.223	.109	.366	82.690	2.085	.925	14.500
Average of the 60 Coal-measures soils	4.150	6.166	.208	.103	.134	.244	87.698	1.695	1.268	. . . .
(4.) Conglomerate or Millstone Grit Soils.										
Rockcastle Co. Vol. V, N. S., p. 469—No. 2231	4.150	3.877	.085	.120	.083	.100	90.665	.900	.671	21.400
Whitley Co. Vol. IV, N. S., p. 146—No. 1961	3.075	3.429	.115	.080	.061	.194	91.105	1.200	.692	20.000
Average of the 2 Conglomerate soils	3.612	3.653	.100	.100	.072	.147	90.885	1.050	.681	20.700
(5.) Upper Sub-carboniferous Soils.										
Crittenden Co. Vol. V, N. S., p. 418—average of 4 soils and subsoils	2.830	6.347	.186	.345	.087	.173	88.825	. . . .	. . . .	n. e.
Grayson Co. Vol. I, N. S., p. 233—average of 6 soils and subsoils	3.929	7.343	.181	.159	.160	.200	87.230	2.229	1.199	n. e.
Hardin Co. Vol. I, N. S., p. 253—average of 25 soils and subsoils	2.838	9.191	.257	.237	.129	.270	86.438	1.735	.885	n. e.
Logan Co. Vol. V, N. S., p. 215—average of 7 soils and subsoils	3.067	7.105	.291	.204	.101	.158	88.113	2.260	1.266	n. e.
Average of the 42 Upper Sub-carboniferous soils,	3.031	8.308	.245	.235	.125	.232	87.058	1.910	1.005	n. e.
(6.) Lower Sub-carboniferous Soils.										
Adair Co. Vol. 2, O. S., p. 129—1 soil	4.440	4.841	.196	.046	.065	.075	90.446	. . . .	. . . .	n. e.
Bath Co. Vol. 3, O. S., p. 77—average of 4 soils and subsoils	4.551	6.800	.132	.395	.158	.158	88.605	. . . .	. . . .	n. e.
Average of the 5 Lower Sub-carboniferous soils,	4.529	6.408	.145	.325	.159	.161	88.973	. . . .	. . . .	. . . .
(7.) Waverly or Knob Formation Soils.										
Hardin Co. Vol. 3, O. S., p. 285—average of 4 soils and subsoils	2.644	4.307	.116	.232	.108	.109	92.334	n. e.	n. e.	. . . .
Monroe Co. Vol. 2, O. S., p. 246—1 soil	4.130	4.936	.106	.200	.075	.119	89.393	n. e.	n. e.	. . . .

TABLE A.—AVERAGE COMPOSITION OF SOILS—Continued.

	Organic and volatile matters.	Alumina and iron and manganese oxides.	Lime carbonate.	Magnesia.	Phosphoric acid (P_2O_5).	Potash, extracted by acids.	Sand and insoluble silicates.	Water expelled at 212° F.	Potash in the insoluble silicates.	Rock fragments, gravel, pebbles, or sand.
(7.) WAVERLY OR KNOB SOILS—Continued.										
Rowan Co. Vol. 4, O. S., p. 253—average of 2 soils and subsoils	4.629	2.972	0.207	0.295	0.086	0.295	88.470	n. e.	n. e.	. . . .
Russell Co. Vol. 2, O. S., p. 259—1 soil	4.170	4.478	.176	.066	.088	.063	90.786	n. e.	n. e.	. . . .
Taylor Co. Vol. 3, O. S., p. 395—average of 2 soils and subsoils	6.445	5.157	.147	.429	.126	.135	86.337	n. e.	n. e.	. . . .
Average of the 10 Waverly soils	4.102	4.290	.145	.264	.101	.148	89.913	n. e.	n. e.	. . . .
(8.) BLACK SLATE (OHIO SHALE) SOILS.										
Bullitt Co. Vol. 3, O. S., p. 227—1 soil	5.665	7.432	.196	.526	.253	.258	85.056	n. e.	n. e.	. . . .
Madison Co. Vol. 4, O. S., p. 213—1 soil	6.125	13.230	.095	.385	.271	.121	79.270	n. e.	n. e.	. . . .
Madison Co. Vol. 4, O. S., p. 214—average of 3 soils and subsoils	10.513	11.487	.845	.907	.222	.088	74.470	. . . .	n. e.	. . . .
Madison Co. Vol. V, N. S., p. 221—1 soil	5.825	10.434	.615	.043	.301	.379	78.965	1.537	n. e.	. . . .
Marion Co. Vol. 4, O. S., p. 313—average of 3 soils and subsoils	4.405	9.910	.280	.337	.207	.183	84.827	n. e.	n. e.	. . . .
Average of the 9 Black Slate soils	5.929	10.587	.475	.524	.234	.178	80.131	. . . .	. . . .	. . . .
(9.) CORNIFEROUS LIMESTONE SOILS.										
Jefferson Co. Vol. 4, O. S., p. 192—average of 6 soils and subsoils	4.158	6.615	.304	.563	.350	.229	87.355	. . . .	. .	0
Madison Co. Vol. V, N. S., p. 454—average of 3 soils and subsoils	5.113	10.763	1.318	.653	.287	.517	79.428	3.208	1.776	0

Nelson Co. Vol. 4, O. S., p. 232—average of 6 soils and subsoils.	5.965	10.655	.209	.676	.257	.395	81.720	n. e.	n. e.	n. e.
Average of the 15 Corniferous Limestone soils,	5.071	9.060	.469	.626	.279	.343	83.517	. . . .	. . .	. . . .
(10.) Upper Silurian Soils.										
Bath Co. Vol. 4. O. S., p. 73—average of 4 soils and subsoils.	6.486	10.759	.314	.554	.204	.249	84.429	n. e.	n. e.	n. e.
Fleming Co. Vol. 4, O. S., p. 152—average of 3 soils and subsoils.	8.775	16.188	.428	.807	.223	.330	69.928	n. e.	n. e.	n. e.
Jefferson Co. Vol. 2, O. S., p. 220—average of 5 soils and subsoils.	5.548	9.771	.279	.249	.223	.215	84.269	n. e.	n. e.	n. e.
Lewis Co. Vol. 4, O. S., p. 199—average of 4 soils and subsoils	4.935	6.857	.304	.467	.112	.203	87.360	n. e.	n. e.	n. e.
Average of the 16 Upper Silurian soils . . .	6.234	10.493	.322	.422	.190	.242	82.395	n. e.	n. e.	n. e.
(11.) Silicious Mudstone (or Middle Hudson) Soils.										
Fayette Co. Vol. 2, O. S., p, 162—1 soil. .	4.881	10.306	.276	.133	.254	.139	83.834	4.12	n. e.	n. e.
Grant Co. Vol. 3, O. S., p. 272—average of 4 soils and subsoils.	4.764	6.115	.209	.421	.216	.181	87.784	n. e.	n. e.	n. e.
Owen Co. Vol. 4, O. S., p. 245—average of 6 soils and subsoils.	4.771	7.157	trace.	.807	.162	.142	86.182	n. e.	n. e.	n. e.
Average of the 11 Middle Hudson soils . . .	4.778	7.034	.101	.605	.165	.155	86.551	n. e.	n. e.	n. e.
(12.) Lower Silurian (Trenton) Limestone Soils ("Blue Grass Soils").										
Bath Co. Vol. 4, O. S., pp. 72–75—average of 4 soils and subsoils.	7.895	8.664	.543	.665	.369	.315	81.690	n. e.	n. e.	0
Bracken Co. Vol. 4, O. S., pp. 84–91—average of 4 soils and subsoils	6.760	11.716	.839	1.338	.290	.304	77.537	n. e.	n. e.	0
Clark Co. Vol. 4, O. S., p. 115—average of 6 soils and subsoils.	6.814	11.086	.383	.807	.275	.475	79.057	n. e.	n. e.	0
Fayette Co. Vol. 1, O. S., pp. 276–8—average of 2 soils and subsoils	6.990	11.034	.783	.250	.422	.172	80.170	n. e.	n. e.	0

TABLE A.—AVERAGE COMPOSITION OF SOILS—Continued.

	Organic and volatile matters.	Alumina and iron and manganese oxides.	Lime carbonate.	Magnesia.	Phosphoric acid (P_2O_5).	Potash, extracted by acids.	Sand and insoluble silicates.	Water expelled at 212° F.	Potash in the insoluble silicates.	Rock fragments, gravel, pebbles, or sand.
(12.) LOWER SILURIAN (TRENTON) LIMESTONE SOILS ("BLUE GRASS SOILS")—Continued.										
Fayette Co. Vol. I, N. S., p. 204—average of 2 soils and subsoils	6.457	8.545	.592	.343	.433	.208	82.403	n. e.	1.080	0
Fayette Co. Vol. IV, N. S., pp. 66–8—average of 5 soils and subsoils	4.874	13.329	.454	.278	.414	.504	78.558	2.733	.972	0
Fleming Co. Vol. 4, O. S., p. 153—average of 3 soils and subsoils	6.143	12.077	.545	.705	.287	.565	79.378	n. e.	n. e.	0
Mason Co. Vol. 4, O. S., p. 217—average of 3 soils and subsoils	6.606	9.422	.269	.741	.229	.483	81.520	n. e.	n. e.	0
Woodford Co. Vol. 4, O. S., p. 281—average of 3 soils and subsoils	6.578	13.359	2.891	.287	.347	.366	76.098	n. e.	n. e.	0
Average of the 32 "Blue Grass soils"	6.211	11.200	.749	.644	.328	.404	73.380	. . . .	. . .	. . . .
(13.) BIRDSEYE LIMESTONE SOILS.										
Garrard Co. Vol. 3, O. S., pp. 303–4—average of 2 soils	3.973	6.455	.667	.583	.249	.228	82.160	n. e.	n. e.	0
Jessamine Co. Vol. 4, O. S., pp. 157–8—average of 4 soils	4.493	6.542	.320	.282	.186	.153	87.620	n. e.	n. e.	
Average of the 6 Birdseye Limestone soils	4.453	6.513	.433	.383	.207	.178	85.800	. . . .	. .	. . . .

TABLE B.

SUMMARY OF THE AVERAGES OF THE KENTUCKY SOILS FROM THE VARIOUS GEOLOGICAL FORMATIONS.

	Organic and volatile matters.	Alumina and iron and manganese oxides.	Lime carbonate.	Magnesia.	Phosphoric acid (P_2O_5).	Potash, extracted by acids.	Sand and insoluble silicates.	Water expelled at 212° F.	Potash in the insoluble silicates.	Rock fragments, gravel, pebbles, or sand.
(1.) Average of 3 Ohio Valley Alluvial soils	3.472	9.835	0.102	0.189	0.118	0.450	84.310	2.513	1.405	0
Average of 2 Miss. Valley Alluvial soils	9.305	10.437	1.385	.461	.198	.142	74.840	4.100	1.889	0
(2.) Average of 21 Quaternary (Loess) soils. .	2.937	6.941	.370	.292	.118	.257	88.098	2.271	1.706	0
(3.) Average of 60 Coal-measures soils	4.150	6.166	.208	.103	.134	.244	87.698	1.695	1.268	n. e.
(4.) Average of 2 Conglomerate soils	3.612	3.653	.100	.100	.072	.147	90.885	1.050	.681	20.700
(5.) Av'ge of 42 Upper Sub-carboniferous soils,	3.031	8.308	.245	.235	.125	.232	87.058	1.910	1.005	n. e.
(6.) Av'ge of 5 Lower Sub-carboniferous soils	4.529	6.408	.145	.325	.159	.161	88.973	n. e.	n. e.	n. e.
(7.) Average of 10 Waverly soils	4.102	4.290	.145	.264	.101	.148	89.913	n. e.	n. e.	n. e.
(8.) Average of 9 Black Slate soils.	5.929	10.587	.475	.524	.234	.178	80.131	n. e.	n. e.	n. e.
(9.) Average of 15 Corniferous Limestone soils,	5.071	9.060	.469	.626	.279	.343	83.517	n. e.	n. e.	0
(10.) Average of 16 Upper Silurian soils. . .	6.234	10.493	.322	.422	.190	.242	82.395	n. e.	n. e.	0
(11.) Average of 11 Silicious Mudstone (Middle Hudson) soils	4.778	7.064	.101	.605	.165	.155	86.551	n. e.	n. e.	n. e.
(12.) Average of 32 Trenton ("Blue") Limestone soils.	6.211	11.200	.749	.644	.328	.404	73.380	n. e.	n. e.	0
(13.) Average of 6 Birdseye Limestone soils . .	4.453	6.513	.453	.383	.207	.178	85.800	n. e.	n. e.	0
Average of the 234 Kentucky soils	4.470	7.998	.355	.336	.177	.262	84.632	. . . .	. . . .	. . . .

TABLE C.

COMPOSITION OF TWO OF THE POOREST SOILS OF KENTUCKY.

Old field soil, Hardin Co.—No. 644	2.309	3.356	.097	.191	.078	.075	93.495	1.500	n. e.	1.60
Virgin soil, Wayne Co.—No. 2253.	1.850	2.836	.195	.073	.029	.021	94.590	.440	.711	33.40

TABLE D.

COMPOSITION OF THREE OF THE RICHEST SOILS OF KENTUCKY, ON THE LOWER SILURIAN LIMESTONE, &C.

	Organic and volatile matters.	Alumina and iron and manganese oxides.	Lime carbonate.	Magnesia.	Phosphoric acid (P_2O_5).	Potash, extracted by acids.	Sand and insoluble silicates.	Water expelled at 212° F.	Potash in the insoluble silicates.	Rock fragments, gravel, pebbles, or sand.
Virgin soil, Campbell Co.—No. 1329	7.615	12.185	0.990	0.520	0.483	0.726	75.590	5.075	2.731	0
Soil, 12 years in cultivation, Jessamine Co.—No. 665	9.745	15.500	3.570	1.290	.532	.569	69.070	6.775	. . . .	. . . .
Virgin soil, Mercer Co.—No. 681	10.365	13.126	1.995	1.234	.333	.762	72.035	4.500	. . . .	. . . .
Composition of very rich soil, so-called "Red Bud soil," on the Lower Devonian formation.										
Virgin soil, Madison Co.—No. 1127	15.450	9.395	1.295	.750	.252	.753	71.045	. . .	. . . .	. . . .

TABLE E.

EXAMPLES OF COMPOSITION OF FOREIGN SOILS (*Traité des Terres Arables, par M. D. Gasparin: Paris*, 1877).

			Lime.							
Ancient volcanic soil, celebrated for its fertility ("*Pont-du-Château, Limagne d'Auvergne*") . . .	5.390	15.330	3.852	.762	.416	.280	66.89	. .	.	16.00
Vineyard soil, Morges, Vaud (Switzerland) . .	2.151	8.022	2.652	1.247	*.093	.246	80.126	. . . .	. . .	19.05

* M. De Gasparin remarks that this is a "good average" of phosphoric acid.

TABLE F.

EXAMPLE OF THE CHANGE IN COMPOSITION CAUSED BY CULTIVATION OF SOILS.

	Organic and volatile matters.	Alumina and iron and manganese oxides.	Lime carbonate.	Magnesia.	Phosphoric acid (P_2O_5).	Potash, extracted by acids.	Sand and insoluble silicates.	Water expelled at 212° F.	Potash in the insoluble silicates.	Rock fragments, gravel, pebbles, or sand.
Virgin soil, Campbell Co.—No. 1324	3.650	6.559	.130	.034	.145	.120	87.545	1.765	n. e.	. . . .
Old field soil, Campbell Co.—No. 1325, more than 40 years in cultivation.	2.555	6.490	.090	.496	.109	.062	89.335	1.550	n. e.	. . . .

REVIEW OF THE AVERAGES OF COMPOSITION OF THE KENTUCKY SOILS ON THE SEVERAL GEOLOGICAL FORMATIONS.

1. *Alluvial Soils.*—Made up of the finer and richer materials of the uplands; present, generally, more than the average proportions of essential elements and conditions, except that in the Ohio Valley soils organic matters are somewhat below average in some. The Mississippi Valley soils contain more organic matters, clay, carbonate of lime, phosphoric acid, and magnesia than the Ohio river soils. These latter have more potash.

2. *Quaternary Soils.*—Have less than average organic matters and of phosphoric acid; enough alumina and iron oxide, lime and magnesia, and average potash.

3. *The Coal Measures Soils.*—Present, generally, an average composition, to be discounted by variable quantities of fragments of rock or gravel.

4. *The Conglomerate Soils.*—Contain less than the average of all the essential elements; more than the average of sand and insoluble silicates, and are to be discounted by variable proportions of pebbles, gravel, &c. Yet no soil is so poor that it may not be made productive by the judicious use of fertilizers, if it has sufficient drainage.

5. *The Upper Sub-carboniferous Soils.*—Contain less than the average of organic matters, but in other respects present nearly an average composition.

6. *The Lower Sub-carboniferous Soils.*—Contain nearly average proportions, except that their carbonate of lime and potash are somewhat below, and their sand and insoluble silicates exceed slightly. Gravel in variable, generally small, proportions, is sometimes present.

7. *Waverly Soils.*—Contain less than average alumina and iron oxide, phosphoric acid and carbonate of lime, magnesia and potash, and more than average sand and insoluble silicates.

8. *Black Slate Soils.*—Contain more than average proportions of organic matters, alumina and iron oxide, lime, magnesia, and phosphoric acid, and less than average potash, and sand and insoluble silicates, but sometimes need drainage.

9. *Corniferous Limestone Soils.*—Have more than average organic matters, alumina and iron oxide, lime, magnesia, phosphoric acid, and potash, and less than average sand and silicates.

10. *Upper Silurian Soils.*—Contain more than average proportions of nearly all the essential ingredients, and less than average potash, and sand and silicates.

11. *Silicious Mudstone (Middle Hudson) Soils.*—Contain average organic matters, alumina and iron oxide and phosphoric acid; more than average magnesia, and sand and insoluble silicates, and less than the average of carbonate of lime and potash.

12. *Blue Limestone (Trenton) Soils.* — Contain much more than average proportions of all the essential elements; less than average sand and insoluble silicates. The richest of all the soils.

13. *Birdseye Limestone Soils.* — Average organic matters, alumina and iron oxide; more than the average lime, magnesia, phosphoric acid, and sand and insoluble silicates, and less than average potash.

By reference to Tables C, D, and E, the comparison may easily be made of the relative composition of known rich and poor soils.

By Table E we may compare our Kentucky soils with celebrated European soils, as reported by one of the most experienced agricultural chemists.

Table F gives one of the many examples which might be quoted of the changes of chemical composition of the soil which results from long cultivation without manures.

That the reader may appreciate the significance of the percentage given in these tables, the writer will state that, by actual measurement and weighing of some of the rich soil of the Blue Grass Region, he found a cubic foot, in its ordinary

condition, to weigh 71.543 pounds. Calculated to the depth of one foot, the soil on an acre would weigh 3,116,413 pounds. Other soils, especially poor, sandy soils, weigh much more than this.

When we calculate into this quantity of soil the 0.404 per cent. of potash, which appears as the average quantity in 32 Blue Grass soils, we find that it amounts to more than twelve thousand five hundred and ninety (12,590) pounds to the acre. On the other hand, taking the small proportion contained in the Old Field soil (Table F), only .062 per cent., the quantity in the acre to the depth of one foot is only one thousand nine hundred and thirty-two (1,932) pounds.

NOTE.—In the early period of the Geological Survey of Kentucky, the late Dr. D. D. Owen gave special attention to the study of the changes in composition, produced in the soil by cultivation without manures, and consequently collected, for comparative chemical analysis, many samples of *Virgin Soil* with that of an immediately neighboring field which had been long in cultivation. Of the one hundred and seventy-three soil analyses made by the writer up to 1860 (see *Vol. IV. O. S. Repts. Ky. Geol. Surv.*, p. 42), this comparison was made in seventy-nine cases; and in seventy-one cases the soil of the old field, as compared with the virgin soil, had lost notable quantities of its essential elements of plant food.

TABLE G.

COMPOSITION OF LIMESTONES OF THE VARIOUS GEOLOGICAL FORMATIONS (DRIED AT 212° F.)

	Specific gravity.	Lime carbonate.	Magnesia carbonate.	Alumina and iron and manganese oxides.	Phosphoric acid (P_2O_5).	Sulphuric acid (SO_3).	Potash.	Soda.	Silica and silicates.	Iron carbonate.
COAL-MEASURES LIMESTONES.										
Carter Co. Vol. I, N. S., p. 192—No. 1390	n. e.	75.750	0.575	6.403	0.057	0.775	n. e.	n. e.	14.700	. . . .
Greenup Co. Vol. I, N. S., p. 241—No. 1498	n. e.	88.410	.797	3.760	.178	.044	.269	.240	5.960	. . . .
Greenup Co. Vol. I, N. S., p. 241—No. 1501	2.770	60.750	25.656	4.167	.013	.315	n. e.	. . .	5.680	3.420
Henderson Co. Vol. 4, O. S., p. 182—No. 1046	2.777	88.380	3.678	1.760	.246	.166	.289	.068	3.280	. . . .
Muhlenburg Co. Vol. 3, O. S., p. 337—No. 705,	n. e.	82.880	4.196	4.333	.247	*4.717	.135	.150	4.260	. . . .
Ohio Co. Vol. V, N. S., p. 229—No. 2073 (*Hydraulic?*)	n. e.	41.680	22.748	8.640	.153	n. e.	1.253	.323	24.060	. . . .
Average composition of the 6 Coal-measures Limestones	2.773	72.958	9.608	4.883	.152	1.003	.486	.195	9.657	. . . .
Average composition of the 2 Magnesian Limestones	. . . .	51.215	24.202	6.403	.083	.315	. . . .	. . . .	14.870	. . .
Average composition of the 4 others	. . . .	83.605	2.312	4.064	.206	1.425	.231	.153	6.550	. . . .

* Equal to 1.891 p. c. of *sulphur*, in the form of yellow pyrites in the limestone.

UPPER SUB-CARBONIFEROUS LIMESTONES.										
Barren Co. Vol. I, N. S., p. 152—No. 1421 (*Oölitic*)	2.678	98.050	.363	.511	.051	.260	.115	.327	1.060	. . . .

TABLE G.—COMPOSITION OF LIMESTONES OF THE VARIOUS GEOLOGICAL FORMATIONS—Continued.

	Specific gravity.	Lime carbonate.	Magnesia carbonate.	Alumina and iron and manganese oxides.	Phosphoric acid (P_2O_5).	Sulphuric acid (SO_3).	Potash.	Soda.	Silica and silicates.	Iron carbonate.
UPPER SUB-CARBONIFEROUS LIMESTONES—Cont'd.										
Barren Co. Vol. I, N. S., p. 152—No. 1422 (*Compact*)	2.721	77.550	13.314	2.680	0.051	0.192	0.154	0.188	6.060	. . . .
Barren Co. Vol. I, N. S., p. 153—No. 1423 (*Lithographic*)	2.689	82.960	7.655	2.680	.115	.260	.135	.156	6.160	. . . .
Butler Co. Vol. I, N. S., p. 169—No. 1314	n. e.	93.020	2.088	.917	.243	.604	n. e.	n. e.	2.760	. . . .
Carter Co. Vol. I, N. S., p. 193—No. 1389	2.700	95.150	.245	1.390	.130	tr.	n. e.	n. e.	3.060	. . . .
Grayson Co. Vol. 4, O. S., p. 159—No. 992	n. e.	85.680	2.503	2.560	.182	.839	.359	tr.	7.480	. . . .
Greenup Co. Vol. I, N. S., p. 241—No. 1499	2.680	88.150	.385	.152	.051	n. e.	n. e.	n. e.	9.560	. . . .
Greenup Co. Vol. I, N. S., p. 241—No. 1500	2.700	92.050	.220	1.490	.128	.199	n. e.	n. e.	4.460	. . . .
Hardin Co. Vol. I, N. S., p. 178—No. 1037 (*Lithographic?*)	n. e.	79.180	11.469	.880	.156	.338	.173	.098	6.980	. . . .
Hardin Co. Vol. I, N. S., p. 178—No. 1039 (*Oölitic*)	n. e.	98.580	.629	.460	.125	.274	.154	.022	.380	. . . .
Average composition of the 10 Upper Sub-carboniferous Limestones	2.694	89.014	3.887	1.292	.123	.371	.181	.132	4.796	. . . .
LOWER SUB-CARBONIFEROUS LIMESTONES.										
Bath Co. Vol. 4, O. S., p. 68—No. 796 (*Hydraulic?*)	2.704	53.240	18.531	9.020	.117	.633	.444	.212	17.540	. . . .
Crittenden Co. Vol. 4, O. S., p. 123—No. 897 (*Hydraulic?*)	2.719	52.880	25.858	1.460	.098	.003	.394	.255	18.880	. . . .
Crittenden Co. Vol. 4, O. S., p. 123—No. 898 (*Hydraulic?*)	2.723	55.280	29.246	1.323	.117	tr.	.344	.056	14.280	. . . .
Average composition of the 3 Lower Sub-carboniferous Limestones	2.715	53.800	24.541	3.601	.111	.218	.394	.141	16.900	. . . .

Black Slate Limestones.										
Bullitt Co. Vol. 2, O. S., p. 141—No. 490 . . .	2.766	63.130	27.760	4.340	.190	*3.770	.440	.150	1.630	. . . .
Madison Co. Vol. 4, O. S., p. 119—No. 888 (*Hydraulic?*)	n. e.	40.280	15.903	9.460	n. e.	1.025	.436	.164	23.180	. . . .
Madison Co. Vol. 4, O. S., p. 212—No. 1123 (*Hydraulic?*)	2.691	49.320	30.729	2.960	.271	.509	.374	.056	14.180	. . . .
Nelson Co. Vol. 3, O. S., p. 343—No. 711 . . .	n. e.	51.660	32.000	5.550	n. e.	.090	.770	.460	9.780	. . . .
Average composition of the 4 Black Slate Limestones	2.728	51.097	26.258	5.578	.230	1.469	.505	.207	12.092	. . . .
* Contains iron pyrites equal 1.51 *sulphur*.										
Corniferous Limestones.										
Madison Co. Vol. V, N. S., p. 451—No. 2199 (*probably hydraulic*)	n. e.	36.580	18.541	5.550		n. e.	n. e.	n. e.	Bitumin 31.090	ous. . . . .
Madison Co. Vol. V, N. S., p. 451—No. 2200 (*probably hydraulic*)	n. e.	47.580	17.135	10.580		n. e.	n. e.	n. e.	18.190	. . . .
Average of the 2 (probably hydraulic) Limestones	. . . .	42.080	17.838	8.065		n. e.	n. e.	n. e.	25.090	. . . .
Jefferson Co. Vol. 4, O. S., p. 195—No. 1077 (*probably Upper Silurian or Niagara*)	n. e.	89.060	6.783	1.480	.310	.475	.154	.163	2.680	. . . .
Jefferson Co. Vol. 4, O. S., p. 195—No. 1078 (*probably Upper Silurian or Niagara*)	n. e.	92.560	4.615	.480	trace.	.166	.166	.070	2.580	. . . .
Average of the 2 Limestones	. .	90.810	5.699	.980	.155	.320	.160	.116	2.630	. . . .
Upper Silurian (Niagara Group) Limestones. (a.) *Magnesia Carbonate above 20 p. c.*										
Bullitt Co. Vol. 4, O. S., p. 105—Nos. 856, 857 (average of 2 samples)	n. e.	51.930	17.662	2.170	trace.	n. e.	.366	.212	6.183	. . . .
Estill Co. Vol. 4, O. S., p. 140—No. 947 (*probably hydraulic*)	n. e.	41.380	30.019	3.546	.374	1.471	.482	.019	18.680	4.321
Garrard Co. Vol. 4, O. S., p. 156—No. 985 (*probaly hydraulic*)	n. e.	34.780	21.470	5.200	.310	.956	.471	.130	35.180	. . . .

TABLE G.—COMPOSITION OF LIMESTONES OF THE VARIOUS GEOLOGICAL FORMATIONS—Continued.

	Specific gravity.	Lime carbonate.	Magnesia carbonate.	Alumina and iron and manganese oxides.	Phosphoric acid (P_2O_5).	Sulphuric acid (SO_3).	Potash.	Soda.	Silica and silicates.	Iron carbonate.
UPPER SILURIAN LIMESTONES—Continued.										
(*a.*) *Magnesia Carbonate above 20 p. c.*										
Madison Co. Vol. V, N. S., p. 449—Nos. 2193-4-5 (average of 3 samples)	n. e.	50.667	24.399	13.398	n. e.	n. e.	0.279	0.064	4.007	. . . .
Nelson Co. Vol. 4, O. S., p. 231—No. 1166 (*a*) (*probably hydraulic*)	n. e.	49.780	34.456	3.000	.246	.475	.270	.006	10.780	. . . .
Nelson Co. Vol. 4, O. S., p. 231—No. 1167 (*probably hydraulic*)	n. e.	50.480	38.154	2.100	.118	.289	.258	.260	8.380	. . . .
Average of the 9 Magnesian Limestones.	n. e.	48.132	25.847	6.541	.175	.797	.339	.115	10.817	. . . .
(*b.*) *Magnesia Carbonate below 20 p. c.*										
Jefferson Co. Vol. 4, O. S., p. 195—average of 5 samples, Nos. 1077, 1078, 1079, 1080, & 1081	n. e.	87.780	7.096	.726	.386	.358	.140	.141	3.480	. . . .
CLINTON GROUP LIMESTONES.										
Bath Co. Vol. 4, O. S., p. 68—No. 796 (*probably hydraulic*)	n. e.	53.240	18.531	9.020	.117	.633	.444	.212	17.540	. . . .
Bath Co. Vol. 4, O. S., p. 68—No. 797	n. e.	51.580	28.779	11.408	.592	.235	.209	trace.	1.980	3.095
Fleming Co. Vol. 4, O. S., p. 151—No. 973 (*probably hydraulic*)	n. e.	42.680	25.358	12.434	.848	.324	.290	.033	10.880	5.155
Average of the 3 Clinton Limestones	n. e.	49.167	24.233	10.954	.519	.364	.314	.122	12.467	. . . .

UPPER HUDSON GROUP LIMESTONES.										
Mason Co. Vol. 4, O. S., p. 217—No. 1131 . .	n. e.	75.440	4.783	3.751	.409	.474	.540	.292	14.440	. . . .
Mason Co. Vol. 4, O. S., p. 217—No. 1132 . .	n. e.	87.980	1.721	2.200	.348	.372	.289	.047	6.380	. . . .
Mason Co. Vol. 4, O. S., p. 217—No. 1133. . .	n. e.	77.360	2.307	3.910	.310	*2.433	.424	.068	13.980	. . . .
Average of the 3 Upper Hudson Limestones. .	n. e.	80.260	2.934	3.287	.356	1.093	.418	.139	11.600	. . . .
* Derived from iron pyrites in the limestone.										
MIDDLE HUDSON GROUP (*Silicious Mudstone of Dr. Owen.*)										
Bracken Co. Vol. III, N. S., p. 166—No. 1307 .	n. e.	.500	.345	14.959	.486	n. e.	2.735	1.515	76.060	. . . .
Bracken Co. Vol. 4, O. S., p. 83—No. 824 . . .	n. e.	.920	1.887	6.460	.438	.200	.560	.166	88.580	. . . .
Fayette Co. Vol. 2, O. S., p. 164—No. 505 . . .	n. e.	trace.	1.410	8.650	.250	.220	.270	.140	87.830	. . . .
Fayette Co. Vol. 2, O. S., p. 164—No. 506 . . .	n. e.	1.790	2.300	10.250	.500	.920	.410	.010	83.450	. . . .
Grant Co. Vol. 3, O. S., p. 276—No. 631	n. e.	.563	1.608	6.202	.378	.117	.363	.200	89.620	. . . .
Nicholas Co. Vol. 3, O. S., p. 360—No. 731 . .	n. e.	.743	.676	8.850	.572	.100	.473	.233	88.440	. . . .
Scott Co. Vol. 4, O. S., p. 254—No. 1225. .	n. e.	3.784	3.401	9.140	.566	.303	.579	.047	77.840	. . .
Average of the 7 "Silicious Mudstones"	n. e.	1.185	1.661	9.216	.456	.265	.413	.330	84.545	. . . .
LOWER HUDSON GROUP LIMESTONES.										
Anderson Co. Vol. 2, O. S., p. 132—Nos. 485–6 (average of 2 samples)	n. e.	85.200	1.240	2.030	.185	.170	.500	.290	10.425	. . . .
Bourbon Co. Vol. 3, O. S., p. 223—Nos. 578–9 (average of 2 samples).	n. e.	96.510	1.049	.542	.138	.180	.075	.174	1.886	. . . .
Franklin Co. Vol. 2, O. S., p. 173—No. 516 . .	n. e.	92.650	1.540	1.190	.090	1.270	.300	.130	3.680	. . . .
Mercer Co. Vol. 3, O. S., p. 325—No. 685 . . .	n. e.	88.900	1.468	2.340	.631	.235	.168	.053	7.185	. . . .
Nicholas Co. Vol. 3, O. S., p. 361—No. 732 .	n. e.	78.680	1.566	2.480	.247	.270	.173	.172	16.640	. . . .
Owen Co. Vol. 3, O. S., p. 376—No. 742. . . .	n. e.	92.920	.559	3.580	.349	.338	.162	.160	1.720	. . . .
Woodford Co. Vol. 2, O. S., p. 280—No. 549. .	n. e.	96.240	.945	1.040	.630	.178	.480	.390	.780	. . . .
Average of the 9 Lower Hudson Limestones . .	. . . .	90.312	1.563	1.753	.288	.332	.270	.203	6.070	. . . .
TRENTON GROUP LIMESTONES.										
(*a.*) *Magnesia Carbonate below 5 p. c.*										
Clark Co. Vol. 4, O. S., p. 114—No. 876. . . .	2.735	85.560	3.567	3.280	.118	.474	.422	.462	5.920	. . . .
Fayette Co. Vol. 4, O. S., p. 149—No. 970 .	n. e.	91.480	1.044	3.980	.848	.317	.232	.336	2.380	. . . .

TABLE G.—COMPOSITION OF LIMESTONES OF THE VARIOUS GEOLOGICAL FORMATIONS—Continued.

	Specific gravity.	Lime carbonate.	Magnesia carbonate.	Alumina and iron and manganese oxides.	Phosphoric acid (P_2O_5).	Sulphuric acid (SO_3).	Potash.	Soda.	Silica and silicates.	Iron carbonate.
UPPER SILURIAN LIMESTONES—Continued.										
(*a.*) *Magnesia Carbonate above 20 p. c.*										
Madison Co. Vol. V, N. S., p. 449—Nos. 2193-4-5 (average of 3 samples)	n. e.	50.667	24.399	13.398	n. e.	n. e.	0.279	0.064	4.007	. . . .
Nelson Co. Vol. 4, O. S., p. 231—No. 1166 (a) (*probably hydraulic*)	n. e.	49.780	34.456	3.000	.246	.475	.270	.006	10.780	. . . .
Nelson Co. Vol. 4, O. S., p. 231—No. 1167 (*probably hydraulic*)	n. e.	50.480	38.154	2.100	.118	.289	.258	.260	8.380	. . . .
Average of the 9 Magnesian Limestones. . .	n. e.	48.132	25.847	6.541	.175	.797	.339	.115	10.817	. . . .
(*b.*) *Magnesia Carbonate below 20 p. c.*										
Jefferson Co. Vol. 4, O. S., p. 195—average of 5 samples, Nos. 1077, 1078, 1079, 1080, & 1081 .	n. e.	87.780	7.096	.726	.386	.358	.140	.141	3.480	. . . .
CLINTON GROUP LIMESTONES.										
Bath Co. Vol. 4, O. S., p. 68—No. 796 (*probably hydraulic*)	n. e.	53.240	18.531	9.020	.117	.633	.444	.212	17.540	. . . .
Bath Co. Vol. 4, O. S., p. 68—No. 797	n. e.	51.580	28.779	11.408	.592	.235	.209	trace.	1.980	3.095
Fleming Co. Vol. 4, O. S., p. 151—No. 973 (*probably hydraulic*)	n. e.	42.680	25.358	12.434	.848	.324	.290	.033	10.880	5.155
Average of the 3 Clinton Limestones . . .	n. e.	49.167	24.233	10.954	.519	.364	.314	.122	12.467	. . . .

UPPER HUDSON GROUP LIMESTONES.										
Mason Co. Vol. 4, O. S., p. 217—No. 1131 . .	n. e.	75.440	4.783	3.751	.409	.474	.540	.292	14.440	. . . .
Mason Co. Vol. 4, O. S., p. 217—No. 1132 . .	n. e.	87.980	1.721	2.200	.348	.372	.289	.047	6.380	. . . .
Mason Co. Vol. 4, O. S., p. 217—No. 1133. . .	n. e.	77.360	2.307	3.910	.310	*2.433	.424	.068	13.980	. . . .
Average of the 3 Upper Hudson Limestones. .	n. e.	80.260	2.934	3.287	.356	1.093	.418	.139	11.600	. . . .
* Derived from iron pyrites in the limestone.										
MIDDLE HUDSON GROUP (*Silicious Mudstone of Dr. Owen.*)										
Bracken Co. Vol. III, N. S., p. 166—No. 1307 .	n. e.	.500	.345	14.959	.486	n. e.	2.735	1.515	76.060	. . . .
Bracken Co. Vol. 4, O. S., p. 83—No. 824 . . .	n. e.	.920	1.887	6.460	.438	.200	.560	.166	88.580	. . . .
Fayette Co. Vol. 2, O. S., p. 164—No. 505 . . .	n. e.	trace.	1.410	8.650	.250	.220	.270	.140	87.830	. . . .
Fayette Co. Vol. 2, O. S., p. 164—No. 506 . . .	n. e.	1.790	2.300	10.250	.500	.920	.410	.010	83.450	. . . .
Grant Co. Vol. 3, O. S., p. 276—No. 631	n. e.	.563	1.608	6.202	.378	.117	.363	.200	89.620	. . . .
Nicholas Co. Vol. 3, O. S., p. 360—No. 731 . .	n. e.	.743	.676	8.850	.572	.100	.473	.233	88.440	. . . .
Scott Co. Vol. 4, O. S., p. 254—No. 1225. .	n. e.	3.784	3.401	9.140	.566	.303	.579	.047	77.840	. . . .
Average of the 7 "Silicious Mudstones"	n. e.	1.185	1.661	9.216	.456	.265	.413	.330	84.545	. . . .
LOWER HUDSON GROUP LIMESTONES.										
Anderson Co. Vol. 2, O. S., p. 132—Nos. 485-6 (average of 2 samples)	n. e.	85.200	1.240	2.030	.185	.170	.500	.290	10.425	. . . .
Bourbon Co. Vol. 3, O. S., p. 223—Nos. 578-9 (average of 2 samples).	n. e.	96.510	1.049	.542	.138	.180	.075	.174	1.886	. . . .
Franklin Co. Vol. 2, O. S., p. 173—No. 516 . .	n. e.	92.650	1.540	1.190	.090	1.270	.300	.130	3.680	. . . .
Mercer Co. Vol. 3, O. S., p. 325—No. 685 . . .	n. e.	88.900	1.468	2.340	.631	.235	.168	.053	7.185	. . . .
Nicholas Co. Vol. 3, O. S., p. 361—No. 732 .	n. e.	78.680	1.566	2.480	.247	.270	.173	.172	16.640	. . . .
Owen Co. Vol. 3, O. S., p. 376—No. 742. . . .	n. e.	92.920	.559	3.580	.349	.338	.162	.160	1.720	. . . .
Woodford Co. Vol. 2, O. S., p. 280—No. 549. .	n. e.	96.240	.945	1.040	.630	.178	.480	.390	.780	. . . .
Average of the 9 Lower Hudson Limestones . .	. . . .	90.312	1.563	1.753	.288	.332	.270	.203	6.070	. . . .
TRENTON GROUP LIMESTONES.										
(a.) *Magnesia Carbonate below 5 p. c.*										
Clark Co. Vol. 4, O. S., p. 114—No. 876. . . .	2.735	85.560	3.567	3.280	.118	.474	.422	.462	5.920	. . . .
Fayette Co. Vol. 4, O. S., p. 149—No. 970 .	n. e.	91.480	1.044	3.980	.848	.317	.232	.336	2.380	. . . .

TABLE G.-COMPOSITION OF LIMESTONES OF THE VARIOUS GEOLOGICAL FORMATIONS - Continued.

	Specific gravity.	Lime carbonate.	Magnesia carbonate.	Alumina and iron and manganese oxides.	Phosphoric acid (P_2O_5).	Sulphuric acid (SO_3).	Potash.	Soda.	Silica and silicates.	Iron carbonate.
TRENTON GROUP LIMESTONES—Continued.										
(*a.*) *Magnesia Carbonate below 5 p. c.*										
Fayette Co. Vol. 2, O. S., p. 165—No. 507 . . .	2.660	92.730	0.630	2.420	0.860	0.340	0 230	0.280	2.180	. . . .
Franklin Co. Vol. 3, O. S., p. 258—No. 615 . .	n. e.	95.380	1.510	.769	.311	.579	.108	.033	2.080	. . . .
Franklin Co. Vol. 2, O. S., p. 172—No. 514 . .	2.699	89.625	.880	.124	.440	.680	.230	.290	6.940	. . . .
Mercer Co. Vol. 4, O. S., p. 221—No. 1143 . .	n. e.	90.720	4.615	2.700	.146	n. e.	.328	.021	1.880	. . . .
Woodford Co. Vol. 2, O. S., p. 279—No. 547 . .	n. e.	91 330	.560	1.530	.700	.330	.340	.430	5.180	. . . .
Average of the 7 Limestones	2.698	90.976	1.828	2.155	.489	.453	.470	.265	3.794	. . . .
(*b.*) *Magnesia Carbonate above 5 p. c.*										
Bourbon Co. Vol. 4, O. S., p. 83—No. 822 . . .	n. e.	75.980	15.595	4.660	.822	.427	.165	.042	2 640	. . .
Bourbon Co. Vol. I, N. S., p. 291—No. 1638 . .	2.600	71.140	11.826	5.890	.511	.240	.231	.252	2.270	. . . .
Fayette Co. Vol. 2, O. S. p. 165—No. 508	2.711	77.630	10.000	3.230	.700	3.120	.320	.150	4.980	. . . .
Fayette Co. Vol. 2, O. S., pp. 168-9 and 170—Nos. 511, 512, 513 (average of 3)	2 675	54 366	35.820	1.750	.310	.230	1.140	.430	5.917	. . .
Fayette Co. Vol. 3, O. S., p. 259—No. 616 . . .	2.728	59.880	37.050	1.380	n. e.	n. e.	.610	.420	2.680	. . . .
Fayette Co. Vol. 4, O. S., p. 149—Nos. 967 and 969 (Ky. Marble, average of 2)	n. e.	70.070	19.252	3 670	.246	.303	.178	.272	4 130	. . . .
Franklin Co. Vol. V, N. S., p. 422—No. 2121 (*Hydraulic?*)	n. e.	70.360	6.784	6.800	n. e.	n. e.	1.118	.281	14.020	. . . .
Madison Co. Vol. 4, O. S., p. 212—No. 1123 (*Hydraulic?*)	2.691	49.320	30.729	2.960	.271	.509	.374	.058	14.160	. . . .
Average of the 11 Magnesian Limestones . . .	2.681	64.323	23.541	3.410	.414	.632	.590	.278	6.078	. . .

BIRDSEYE LIMESTONES.										
Fayette Co. Vol. 4, O. S., p. 149—No. 968 . . .	n. e.	95.680	2.044	.380	.182	.166	.193	.048	1.580	. . . .
Woodford Co. Vol. 2, O. S., p. 280—No. 548 . .	2.705	94.750	1.960	.630	trace.	.300	.230	.032	2.180	. . . .
Average of the 2 Birdseye Limestones	. . . .	95.215	2.002	.505	.091	.233	.207	.040	1.880	. . . .
CHAZY LIMESTONES.										
Mercer Co. Laboratory Book, p. 1358 (No. 1) .	n. e.	62.860	30.720	1.220	n. e.	n. e.	n. e.	n. e.	5.000	. . .
Mercer Co. Laboratory Book, p. 1359 (No. 2) .	n. e.	83.580	10.550	.980	n. e.	n. e.	n. e.	n. e.	5.560	. . . .
Woodford Co. Vol. 3, O. S., p. 409—No. 776 . .	2.655	59.860	36.640	.980	n. e.	.160	.400	.080	2.480	. . . .
Average of the 3 Chazy Limestones	. . . .	68.767	25.970	1.060	n. e.	n. e.	n. e.	n. e.	4.346	. . . .

TABLE H.

GENERAL AVERAGES OF THE COMPOSITION OF THE LIMESTONES OF THE SEVERAL GEOLOGICAL FORMATIONS

(*Including also the Middle Hudson or Silicious Mudstone of Dr. Owen*).

	Specific gravity.	Lime carbonate.	Magnesia carbonate.	Alumina and iron and manganese oxides.	Phosphoric acid (P_2O_5).	Sulphuric acid (SO_3).	Potash.	Soda.	Silica and silicates.
Average composition of 6 Coal-measures Limestones. . .	. . . .	72.958	9.608	4.883	0.152	1.003	0.486	0.195	9.657
Average composition of 2 of these, which are magnesian and probably *Hydraulic*	. . . .	51.215	24.202	6.403	.083	.315	n. e.	n. e.	14.870
Average composition of 4 of these, not unusually magnesian	2.773	83.605	2.312	4.064	.206	1.425	.118	.153	6.550
Average composition of 10 Upper Sub-carboniferous Limestones	2.694	89.014	3.887	1.292	.123	.371	.181	.132	4.796
Average composition of 3 Lower Sub-carboniferous Limestones (*Hydraulic?*)	2.715	53.800	24.541	3.601	.111	.218	.394	.141	16.900
Average composition of 6 Black Slate Limestones. . . .	2.728	51.097	26.258	5.578	.230	1.469	.505	.207	12.092
Average composition of 4 Corniferous Limestones—									
Of which 2 are magnesian (*Hydraulic?*)	n. e.	42.080	17.838	8.065		n. e.	n. e.	n. e.	25.090
And 2 are non-magnesian	n. e.	90.810	5.999	.980	.155	.320	.160	.116	2.630
Average composition of 14 Niagara Group (or Upper Silurian) Limestones	n. e.	62.292	19.150	4.321	.250	.640	.267	.123	8.196
Of which 9 contain more than 20 p. c. of magnesia carbonate, and are probably *Hydraulic*	n. e.	48.132	25.847	6.541	.175	.797	.339	.115	10.817
And 5 contain less than 20 p. c. of magnesia carbonate	n. e.	87.780	7.096	.726	.386	.358	.140	.141	3.480
Average composition of 3 Clinton Group Limestones . .	n. e.	49.167	24.233	10.954	.519	.364	.314	.122	12.467
Average composition of 3 Upper Hudson Group Limestones.	n. e.	80.260	2.934	3.287	.356	1.093	.418	.139	11.600
Average composition of 7 Middle Hudson Group ("Silicious Mudstone")	n. e.	1.185	1.661	9.216	.456	.265	.413	.330	84.545
Average composition of 9 Lower Hudson Limestones . .	n. e.	90.312	1.163	1.753	.288	.332	.270	.203	6.070

Average composition of 7 Trenton Limestones (*non-magnesian*)	2.698	90.976	1.828	2.155	.489	.453	.470	.265	3.794
Average composition of 11 Trenton Limestones (*magnesian*)	2.681	64.323	23.541	3.410	.414	.632	.590	.278	6.078
Average composition of 2 Birdseye Limestones	. . .	95.215	2.002	.505	.091	.233	.207	.040	1.880
Average composition of 3 Chazy Limestones	. . . .	68.767	25.970	1.060	n. e.	n. e.	n. e.	n. e.	4.346

TABLE I.

COMPARATIVE REVIEW OF THE COMPOSITION OF THE LIMESTONES (*excluding the Silicious Mudstone*).

RELATIVE PROPORTIONS OF LIME CARBONATE.

The largest Average Proportions are in—	Per cent.	*Medium Average Proportions in—*	Per cent.	*Smallest Average Proportions in—*	Per cent.
Birdseye Limestones	*95.215	Coal-measures Limestones (in general)	72.958	Lower Sub-carboniferous Limestones,	53.800
Trenton Limestones (non-magnesian),	90.976	Chazy Limestones	68.766	Black Slate Limestones	51.270
Corniferous Limestones (resembling Upper Silurian)	90.810	Trenton Limestones (magnesian)	64.323	Coal-measures Limestones (magnesian)	51.215
Lower Hudson Limestones	90.312	Niagara Limestones (in general)	62.292	Clinton Limestones (magnesian)	49.167
Upper Sub-carboniferous Limestones,	89.014			Niagara Limestones (magnesian)	48.132
Niagara Limestones (non-magnesian),	87.780			Corniferous Limestones (magnesian),	42.080
Coal-measures Limestones (non-magnesian)	83.605				
Upper Hudson Limestones	80.260				

* The largest proportions of lime carbonate of all the limestones analyzed were found in the Oölitic limestone of the Upper Sub-carboniferous formation, two samples of which yielded, severally, 98.58 and 98.05 per cent.

TABLE I.—COMPARATIVE REVIEW OF THE COMPOSITION OF THE LIMESTONES—Continued.

RELATIVE PROPORTIONS OF MAGNESIA CARBONATE.

The largest Average Proportions are in—	Per cent.	*Medium Average Proportions in—*	Per cent.	*Smallest Average Proportions in—*	Per cent.
Black Slate Limestones	26.258	Coal-measures Limestones (in general)	9.608	Upper Sub-carboniferous Limestones,	3.887
Chazy Limestones	25.970	Niagara Limestones (non-magnesian)	7.096	Upper Hudson Limestones	2.934
Niagara Limestones (magnesian)	25.847	Corniferous Limestones (non-magnesian)	5.999	Birdseye Limestones	1.828
Lower Sub-carboniferous Limestones,	24.541			Lower Hudson Limestones	1.163
Clinton Limestones	24.233			Middle Hudson Limestones	.970
Coal-measures Limestones (magnesian)	24.202				
Trenton Limestones (magnesian)	23.541				
Niagara Limestones (in general)	19.150				
Corniferous Limestones (magnesian),	17.838				

RELATIVE PROPORTIONS OF ALUMINA AND IRON AND MANGANESE OXIDES.

Clinton Limestones	10.954	Niagara Limestones (general average)	4.321	Lower Hudson Limestones	1.886
Corniferous Limestones (magnesian),	8.065	Trenton Limestones (magnesian)	3.410	Upper Sub-carboniferous Limestones,	1.292
Niagara Limestones (magnesian)	6.541	Lower Sub-carboniferous Limestones,	3.601	Chazy Limestones	1.060
Coal-measures Limestones (magnesian)	6.403	Upper Hudson Limestones	3.287	Corniferous Limestones (non-magnesian)	.980
Black Slate Limestones	5.578	Trenton Limestones (non-magnesian)	2.155	Niagara Limestones (non-magnesian),	.726
Coal-measures Limestones (general average)	4.883			Birdseye Limestones	.505

TABLE I.—COMPARATIVE REVIEW OF THE COMPOSITION OF THE LIMESTONES—Continued.

RELATIVE PROPORTIONS OF PHOSPHORIC ACID (P_2O_5).

The largest Average Proportions are in—	Per cent.	*Medium Average Proportions in—*	Per cent.	*Smallest Average Proportions in—*	Per cent.
Clinton Limestones	0.519	Coal-measures Limestones (non-magnesian)	0.206	Lower Sub-carboniferous Limestones,	0.111
*Trenton Limestones (magnesian)	.489	Niagara Limestones (magnesian)	.175	Birdseye Limestones	.091
Trenton Limestones (non-magnesian),	.414	Upper Sub-carboniferous Limestones,	.123	Chazy Limestones (a trace)	n. e.
Niagara Limestones (small magnesia)	.386				
Upper Hudson Limestones	.356				
Lower Hudson Limestones	.288				
Niagara Limestones (general average),	.250				
Black Slate Limestones	.230				

*In the Trenton limestone, near Lexington, in several localities, irregular layers of highly phosphatic limestone are found. A number of samples analyzed by the writer gave from 5.69 to 21.86 per cent. of phosphoric acid (P_2O_5). The proportion of this valuable ingredient varies greatly in the different beds of this formation, and the general average of it is no doubt greater than appears in these tables.

RELATIVE PROPORTIONS OF SULPHURIC ACID (SO3).

Black Slate Limestones	1.467	Trenton Limestones (non-magnesian)	.435	Corniferous Limestones (magnesian),	.320
Coal-measures Limestones (non-magnesian)	1.425	Upper Sub-carboniferous Limestones,	.371	Coal-measures Limestones (magnesian)	.315
Upper Hudson Limestones	1.093	Clinton Limestones	.364	Birdseye Limestones	.233
Coal-measures Limestones (general average)	1.003	Niagara Limestones (non-magnesian)	.358	Lower Sub-carboniferous Limestones,	.218
Niagara Limestones (magnesian)	.797	Lower Hudson Limestones	.332		
Niagara Limestones (general average),	.640				
Trenton Limestones (magnesian)	.632				

TABLE I.—COMPARATIVE REVIEW OF THE COMPOSITION OF THE LIMESTONES—Continued.

RELATIVE PROPORTIONS OF POTASH.

The largest Average Proportions are in—	Per cent.	*Medium Average Proportions in*	Per cent.	*Smallest Average Proportions in—*	Per cent.
Trenton Limestones (magnesian) . .	0.590	Birdseye Limestones	.207	Corniferous Limestones (non-magnesian)	0.160
Black Slate Limestones.	.505	Upper Sub-carboniferous Limestones,	.181	Niagara Limestones (non-magnesian),	.140
Coal-measures Limestones (general average).	.486			Coal-measures Limestones (non-magnesian)	.118
Trenton Limestones (non-magnesian),	.470				
Upper Hudson Limestones	.418				
Lower Sub-carboniferous Limestones,	.394				
Niagara Limestones (magnesian) . .	.339				
Clinton Limestones	.314				
Lower Hudson Limestones	.270				
Niagara Limestones (general average),	.267				

RELATIVE PROPORTIONS OF SODA.

Middle Hudson Limestones.	.330	Coal-measures Limestones (non-magnesian).	.153	Niagara Limestones (general average)	.123
Trenton Limestones (magnesian) . .	.278	Lower Sub-carboniferous Limestones,	.141	Clinton Limestones	.122
Trenton Limestones (non-magnesian),	.265	Niagara Limestones (non-magnesian).	.139	Corniferous Limestones (non-magnesian)	.116
Black Slate Limestones.	.207	Upper Sub-carboniferous Limestones,	.132	Niagara Limestones (non-magnesian),	.115
Lower Hudson Limestones	.203			Birdseye Limestones	.040
Coal-measures Limestones (general average).	.195				

TABLE I.—COMPARATIVE REVIEW OF THE COMPOSITION OF THE LIMESTONES Continued.

RELATIVE PROPORTIONS OF SILICA AND SILICATES.

The largest Average Proportions in—	Per cent.	*Medium Average Proportions in—*	Per cent.	*Smallest Average Proportions in—*	Per cent.
Corniferous Limestones (magnesian),	25.090	Coal-measures Limestones (general average)	9.657	Trenton Limestones (non-magnesian),	3.794
Coal-measures Limestones (magnesian, only 1 sample)	24.060	Niagara Limestones (general average)	8.196	Niagara Limestones (non-magnesian)	3.480
Lower Sub-carboniferous Limestones,	16.900	Coal-measures Limestones (non-magnesian)	6.550	Corniferous Limestones (non-magnesian)	2.630
Coal-measures Limestones (magnesian)	14.870	Trenton Limestones (magnesian),	6.078	Birdseye Limestones	1.880
Clinton Limestones	12.460	Lower Hudson Limestones	6.055		
Black Slate Limestones	12.092	Upper Sub-carboniferous Limestones,	4.796		
Upper Hudson Limestones	11.600	Chazy Limestones	4.336		
Niagara Limestones (magnesian)	10.817				

GENERAL REMARKS ON THE LIMESTONES OF KENTUCKY.

As may be seen in the appended tables of average chemical composition, these limestones present a great variety, and are applicable to numerous practical uses.

For building stones, the limestones of most of the formations may be employed, those especially which can be quarried of suitable size and form. The best and most durable are those which possess a close, compact or fine granular structure, without cracks or crevices, which consequently would not absorb much water, or be liable to be disintegrated by frost, and which do not contain much iron pyrites or iron protoxide, and are not full of fossils or chert. The most durable of all the limestones hitherto tried are the compact homogeneous layers of the pure magnesian limestone of the Lower Silurian group, of fine granular structure, such as was used in the Clay monument in the cemetery at Lexington. Some of the beds of the Birdseye Limestone are compact enough to receive a good polish, and to take the name of marble. The Lower and Upper Silurian groups, including Lower and Upper Hudson, the Corniferous and Upper Sub-carboniferous groups, as well as some beds of Coal-measures limestones, &c., all include layers sufficiently pure and homogeneous and of proper structure to answer well for building purposes.

The oölitic layers of the Upper Sub-carboniferous formation are remarkably pure carbonate of lime, containing more than 98 per cent. of that material. It would, by calcination, yield a very pure, white lime, which might be utilized in many manufacturing processes. Pulverized, it would prove available in the manufacture of glucose, for neutralizing the sulphuric acid employed, especially as it contains but little magnesia. Some of the layers take a good polish. The Birdseye limestone is also quite pure, and would yield a very white lime. Some of its layers are susceptible of a good polish, and have been used and known as "Kentucky marble." It is quite compact, but somewhat brittle.

Some of the layers of this Sub-carboniferous limestone are available for lithographic purposes. These have been found and quarried in Menifee, Barren, Hardin, Estill, and Meade counties. Their availability for this purpose depends mainly on their fine granular structure, their freedom from fossils, flaws, cracks, or irregularities of texture, and the possibility of obtaining slabs of good size of a homogeneous character. Those which have been analyzed contained a considerable percentage of magnesia carbonate.

All of these limestones could be utilized in the preparation of mortars and cements. Of course those which are the purest would slack the hottest, and give what is technically called "fat lime," and would probably harden in the air more firmly, when mixed with a proper proportion of clean, sharp silicious sand, than the less pure lime, and hence would be preferred by the bricklayer and plasterer, and for preparing the whitest wash; but any of the ordinary limestones of the several geological formations may be used for building purposes, and experience has shown that some of them which contain considerable proportions of silica and silicates, alumina, iron oxide, and magnesia, although their lime may not slack so readily or so hot as that of the purer limestones, yet will resist the action of water and of other atmospheric agencies better than some of those which are purer carbonate of lime.

For *cements*, or mortars which are used to withstand the action of water, so-called *hydraulic or water cements*, what we may call *impure limestones* are generally available. The hydraulic or water limestones frequently contain a considerable proportion of magnesia. Indeed, some quick-setting water limes seem to owe their peculiar property to the admixture of magnesia; but the cement of such limestones is said not to be so durable or so perfectly water-proof as that containing considerable proportions of silica and of alumina and iron oxide. "A very striking proof of the influence of magnesia * * * is afforded by the limestone from Tarnowitz, * * * which hardens extremely well, although it only contains 3.35 per cent. of silica. This limestone contains 29.32

per cent. of carbonate of magnesia." It contains 16.83 per cent. of carbonate of iron, 3.75 of alumina, and 49.06 per cent. of carbonate of lime. (*Knapp's Chem. Technology, vol.* 1, *pp.* 378, 385.) Proportions of potash and soda not given. By reference to our tables of average compositions this will be seen to resemble some of our Kentucky limestones.

The statement of the composition of the celebrated hydraulic limestone from the neighborhood of the Falls of the Ohio river at Louisville, Jefferson county (*see vol.* 2, *O. S., Ky. Geol. Repts., p.* 220), may be given as the type of that of a good hydraulic limestone, dried at 212° F., as follows:

	Per cent.	
Carbonate of lime	50.43	= 28.29 per cent. of lime.
Carbonate of magnesia	18 67	= 8.89 per cent. of magnesia.
Alumina and iron and manganese oxides	2.93	
Phosphoric acid (P2 O5)	.06	
Sulphuric acid (SO3)	1.58	
Potash	.32	
Soda	.13	
Sand and insoluble silicates	25.78	Containing silica = 22.58 per cent.
Loss	.10	
	100.00	

The reader is referred to vol. IV, N. S., of Ky. Geol. Repts., pp. 404 to 408, for more full statements and remarks in relation to hydraulic limestones and cements. According to the experiments and analyses of Berthier and Kersten, 5 to 9 per cent. of silica, alumina, and iron carbonate, with from 0.40 to 5 per cent. of magnesia carbonate in the composition of a limestone, give to it a very moderate hydraulic character, while 13 per cent. of these ingredients, with 4 per cent. of magnesia carbonate, give it marked hydraulic properties. (*Knapp's Chem. Tech., v.* 2, *p.* 379). But, as stated in vol. IV, N. S., of Ky. Geol. Repts., above referred to, the presence of the alkalies, potash, and soda no doubt is an important factor in the composition of a hydraulic limestone.

Limestone, calcined and air-slacked, or simply ground up without calcination, is employed in some localities to improve the quality of the soil, and increase its fertility. It may operate in a variety of modes. Its constant action is to neutralize

acids, and to decompose sulphate of iron and some forms of organic matters, aiding in the formation of ammonia, and favoring nitrification under some circumstances, thus assisting in supplying available nitrogen to crops. Applied in large quantities, as slacked lime, it greatly improves the texture of heavy, tenacious clay soils, rendering them more friable and penetrable by fluids. No doubt, while in the caustic state, slacked lime acts somewhat on the insoluble silicates of the soil, and sets free some of the alkalies and other valuable ingredients. But it is highly probable that the most profitable lime for use as a fertilizer would be that which had in its composition the largest proportions of potash, phosphoric acid, sulphuric acid, soda, &c. These valuable elements of plant food are in largest proportions in the impure limestones, and would be more quickly available in the calcined lime than in the ground limestone. It appears to have become somewhat fashionable to apply ground limestone to the soil as a fertilizer, but unless a limestone very rich in phosphoric acid and potash is selected for this use, it is very questionable whether it would be profitable on any but a soil which was very deficient of lime. The practice of adding ground limestone to commercial fertilizers would generally be profitable to the manufacturer only.

One very important use of limestone is as a flux in the smelting of iron ore. For this purpose a carbonate of lime containing little or no phosphoric acid or sulphuric acid or pyrites (iron sulphide) would be most appropriate. The presence of moderate quantities of silica and silicates, or of magnesia, potash, or soda, would not be objectionable. Indeed, the ferruginous limestones found in the coal-measures would increase the product of iron; and the oxide of manganese, which occurs sometimes in these limestones in notable proportions, would improve the quality of the fluxing material, as well as that of the iron produced.

TABLE J.

AVERAGES OF THE COMPOSITION OF THE CLAYS OF THE SEVERAL GEOLOGICAL FORMATIONS OF KENTUCKY.

(*Dried at* 212° *F.*)

	Silica, &c.	Alumina	Iron peroxide.	Lime.	Magnesia.	Phosphoric acid.	Potash.	Soda.	Water and loss.	Fine sand.
TERTIARY CLAYS (*Dried at* 212° *F.*)										
(1.) FIRE-CLAYS.										
Ballard Co. Vol. V, N. S., p. 411—No. 2104 (*a*),	74.460	18.070	1.633	.314	.245	n. e.	.940	.021	4.317	48.000
Ballard Co. Vol. V, N. S., p. 411—No. 2105 (*a*),	67.501	23.051	2.109	.257	.065	n. e.	.412	.020	6.585	54.000
Fulton Co. Vol. I, N. S., p. 217—No. 1439 (*a*) .	74.960	18.350		.304	.309	.051	.230	.124	5.800	n. e.
Fulton Co. Vol. I, N. S., p. 217—No. 1440 (*a*) .	81.060	13.609		.314	.139	.051	.231	.021	3.600	n. e.
Fulton Co. Vol. V, N. S., p. 430—Nos. 2136 to 2141, inclusive (average of 4 clays) (*a*). . . .	79.735	12.542	2.427	.453	.178	n. e.	.628	.122	3.914	n. e.
Graves Co. Vol. V, N. S., p. 433—No. 2143 (*a*),	*75.555	16.751	1.198	trace.	.144	n. e.	1.094	.216	5.047	*63.000
Hickman Co. Vol. V., N. S., p. 442—No. 2162 (*a*),	*84.918	10.560	1.102	.572	.108	n. e.	.651	n. e.	2.089	*68.500
Average composition of the 10 Tertiary fire-clays,	77.739	14.825	1.969	.358	.172	n. e.	.607	.099	4.309	n. e.
(2.) POTTER'S CLAYS.										
Fulton Co. Vol. V, N. S., p. 430—Nos. 2134–2139, inclusive (average of 4 clays) (*a*). . . .	71.021	17.977	3.417	1.019	.262	n. e.	.721	.229	5.276	n. e.
Hickman Co. Vol. V, N. S., p. 442—No. 2163 (*a*),	76.360	14.951	2.109	.325	.173	n. e.	1.171	.125	4.786	n. e.
Average composition of the 5 Tertiary Potter's Clays	72.088	17.372	3.212	.880	.228	n. e.	.814	.208	5.218	n. e.
COAL-MEASURES CLAYS.										
(1.) FIRE-CLAYS.										
Carter Co. Vol. I, N. S., p. 179—Nos. 1337-8-9 (average of 3), most refractory (*a*).	49.713	36.156	traces.	.086	traces.	.354	.250	.434	13.007	n. e.

Carter Co. Vol. I, N. S., p. 179—Nos. 1340-1-2 (average of 3), less refractory (*a*)	57.427	31.861	trace.	.228	.070	.466	1.188	.609	8.193	n. e.
Greenup Co. Vol. 1, O. S., p. 332—Nos. 124-5 (average of 2), (*a*)	58.740	30.000	n. e.	.067	.073	n. e.	.072	.225	8.915	n. e.
Greenup Co. Vol. I, N. S., p. 236—Nos. 1477-81-83 (average of 3), most refractory (*a*)	54.780	32.678	trace.	.198	.306	.464	.551	.296	10.532	n. e.
Greenup Co. Vol. I, N. S. p. 236—Nos. 1478-79-82 (average of 3), less refractory (*a*)	61.680	24.814	1.270	.232	1.069	.431	1.905	.636	7.934	n. e.
Greenup Co. Vol. I, N. S., p. 236—No. 1480, least refractory (*a*)	47.060	36.620	trace.	.615	.389	.626	1.156	.234	13.300	n. e.
Ohio Co. Vol. V, N. S., p. 230—No. 2076 (*a*)	62.760	24.420	1.580	.325	trace.	n. e.	.906	.268	7.731	5.300
Union Co. Vol. 1, O. S., p. 361—No. 167 (*b*)	73.000	17.600	3.000	.336	n. e.	n. e.	.100		5.700	n. e.
Average composition of the 17 Coal-measures fire-clays	57.159	30.304	1.280	.214	.286	.443	.537	.407	9.621	. .
(2.) Potter's Clays.										
Butler Co. Vol. V, N. S., p. 187—No. 1995 (*a*)	51.660	15.560	7.680	7.269	.817	n. e.	3.276	.293	13.445	n. e.
Ohio Co. Vol. V, N. S., p. 230—Nos. 2074-5 (average of 2 clays) (*a*)	70.060	17.940	.382	trace.	.659	n. e.	2.726	.231	4.563	n. e.
Average composition of the 3 Coal-measures Potter's clays	63.927	17.147	2.815	2.423	.712	n. e.	2.909	.231	7.524	. . .
Black Slate—Potter's Clay.										
Madison Co. Vol. V, N. S., p. 445—No. 2168 (*a*),	62.560	24.780	1.800	trace.	0.317	n. e.	3.276	.294	6.973	. . . .
Crab Orchard Shale (Clinton?)—Potter's Clay.										
Madison Co. Vol. V, N. S., p. 445—Nos. 2169, 2170 (average of the 2) (*a*)	63.573	21.550	3.980	.386	.533	n. e.	5.167	.308	4.655	. . .
Middle Hudson Formation.										
Boone Co. Vol. IV, N. S., p. 35—No. 1697 (*a*)	48.360	33.060		3.057	.367	n. e.	4.664	1.706	8.786	. . . .

TABLE J.—AVERAGES OF THE COMPOSITION OF THE CLAYS OF THE SEVERAL GEOLOGICAL FORMATIONS OF KENTUCKY—Continued.

	Silica, &c	Alumina.	Iron peroxide.	Lime.	Magnesia.	Phosphoric acid.	Potash.	Soda.	Water and loss.	Fine sand.
GENERAL AVERAGES OF THE CLAYS (*Dried at* 212°).										
(1.) FIRE-CLAYS.										
General average composition of 10 Tertiary fire-clays (*a*)	77.739	14.825	1.969	.358	.172	n. e.	.607	.099	4.309	. . . .
General average composition of 17 Coal-measures fire-clays (*a*)	57.159	30.304	1.280	.214	.286	.443	.537	.407	9.621	. . . .
General average composition of the 27 fire-clays (*a*)	67.449	22.564	1.624	.286	.229	. . .	.572	.253	6.965	. . . .
(2.) POTTER'S CLAYS.										
General average of 5 Tertiary Potter's clays (*a*),	72.088	17.372	3.212	.880	.228	n. e.	.814	.208	5.218	. . . .
General average of 3 Coal-measures Potter's clays (*a*)	63.927	17.147	2.815	2.423	.712	n. e.	2.909	.231	7.524	. . . .
General average of 3 Black Slate and Clinton Potter's clays (*a*).	63.235	22.627	3.189	.257	.461	n. e.	4.537	.303	5.428	. . . .
Composition of 1 Middle Hudson Potter's clay (*a*)	48.360	33.060		3.057	.367	n. e.	4.660	1.706	8.786	. . . .
Average composition of the 12 Potter's clays (*a*),	65.857	22.809		1.292	.419	n. e.	2.588	.362	6.144	. . . .
Average proportion of the alumina and iron peroxide in 11 of these clays	. .	18.744	3.096	. . .	. . .	. . . .	. . .	. . .	. .	. . . .

For Comparison, the following Analyses of Foreign Fire-clays are Appended:										
Average composition of 3 German Glass pot clays (vol. IV, N. S., p. 163—Nos. II, I, and J),	71.686	21.320	1.560	.292	.293	n. e.	.549	.079	5.630	. . . .
Composition of Chinese porcelain clay (vol. I, N. S., p. 181) (*a*)	55.300	30.300	2.000	n. e.	.400	n. e.	1.100	2.700	8.200	. . . .
Composition of Stourbridge (England) fire-clay (vol. I, N. S., p. 181) (*a*)	63.400	31.700	3.000	n. e.	n. e.	n. e.	1.900		n. e.	. . . .

(*a*) Analyzed by fusion with alkaline carbonates, &c., &c.
(*b*) Analyzed by digestion in acids, &c.
* Fine sand included in the total silica.

COMPARATIVE REVIEW OF THE AVERAGE COMPOSITION OF THE CLAYS OF THE SEVERAL GEOLOGICAL FORMATIONS, &c.

(*a*.) Fire Clays.

Relative Proportions of Silica, &c.

The largest Average Proportions in—	Per cent.	Medium Proportions in—	Per cent.	Smallest Proportions in—	Per cent.
Tertiary fire-clays	77.739	Stourbridge fire-clay (English) . . .	63.400	Coal-measures fire-clays.	57.159
German glass-pot clays.	71.686			Chinese porcelain clay.	55.300

Relative Proportions of Alumina.

Stourbridge fire-clay	31.700	German glass-pot clays	21.320	Tertiary fire-clays.	14.825
Coal-measures fire-clay.	30.304				
Chinese porcelain clay	30.300				

COMPARATIVE REVIEW OF THE AVERAGE COMPOSITION OF THE CLAYS OF THE SEVERAL GEOLOGICAL FORMATIONS, &c.—Continued.

(*a.*) FIRE-CLAYS.

Relative Proportions of Iron Peroxide.

The largest Average Proportions in—	Per cent.	Medium Proportions in	Per cent.	Smallest Proportions in —	Per cent.
Stourbridge fire-clay	3.000	Tertiary fire-clay	1.969	Coal-measures fire-clays	1.280
Chinese porcelain clay	2.000	German glass-pot clay	1.500		

Relative Proportions of Lime.

Tertiary fire-clays	.385	German glass-pot clays	.292	Coal-measures fire-clays	.214

Relative Proportions of Magnesia.

Chinese porcelain clay	.400	German glass-pot clays	.293	Tertiary fire-clays	.172
		Coal-measures fire-clays	.286		

Relative Proportions of Potash.

Chinese porcelain clay	1.100	Tertiary fire-clays	.607	Coal-measures fire-clays	.537
		German glass-pot clays	.549		

Relative Proportions of Soda.

The largest Average Proportions in—	Per cent.	Medium Average Proportions in—	Per cent.	Smallest Average Proportions in—	Per cent.
Chinese porcelain clay	2.700	Coal-measures fire-clays	0.407	Tertiary fire-clays	0.099
				German glass-pot clays	.079

(*b.*) POTTER'S CLAYS.

Relative Proportions of Silica, &c.

Tertiary clays	72.088	Coal-measures clays	63.927	Middle Hudson clays	48.360
		Black Slate clays	63.235		

Relative Proportions of Alumina.

Black Slate clays	22.627			Tertiary clays	17.372
				Coal-measures clays	17.147

Relative Proportions of Iron Peroxide.

Tertiary clays	3.212	Coal-measures clays	2.815		
Black Slate clays	3.189				

COMPARATIVE REVIEW OF THE AVERAGE COMPOSITION OF THE CLAYS OF THE SEVERAL GEOLOGICAL FORMATIONS, &c.—Continued.

(*b.*) POTTER'S CLAYS.

Relative Proportions of Lime.

The largest Average Proportions in—	Per cent.	Medium Average Proportions in—	Per cent.	Smallest Average Proportions in—	Per cent.
Middle Hudson clays	3.057	Coal-measures clays	2.057	Tertiary clays	0.880
				Black Slate clays	.257

Relative Proportions of Magnesia.

Coal-measures clays	.712	Black Slate clays	.461	Tertiary clays	.228
		Middle Hudson clays	.367		

Relative Proportions of Potash.

Middle Hudson clays	4.660	Coal-measures clays	2.903	Tertiary clays	.814
Black Slate clay	4.537				

Relative Proportions of Soda.

Middle Hudson clays	1.706	Black Slate clays	.303	Coal-measures clays	.231
				Tertiary clays	.208

GENERAL REMARKS ON THE KENTUCKY FIRE-CLAYS.

It will be seen that the best and greatest quantities of our fire-clays hitherto observed are found in the Coal-measures and Tertiary formations. In the former they are usually in an indurated condition, requiring grinding or exposure to the atmospheric agencies to make them plastic. In the Tertiary beds they are more friable, and easily to be kneaded with water. This marked difference is greatly owing to difference in composition. The Tertiary clays contain much more silica and less alumina than those of the Coal-measures, and much of this silica is in the form of fine sand, as may be seen by reference to the foregoing tables. This causes the Tertiary clays to be less plastic and adhesive than those of the Coal-measures, but probably may cause them to be rather more refractory in the fire. The plastic clays or Potter's clays have not been examined in so large number as the fire-clays, but have a wider range in the several geological formations. All forms of clays have numerous industrial applications, varying from the most costly products of the ceramic art to the rude brick or draining tile.

Influence of the Several Chemical Ingredients of Clays.

Pure hydrated aluminum silicate, which is the essential basis of all clays, has a composition represented by 46.3 per cent. of silica, 39.8 per cent. of alumina, and 13.9 per cent. of water. = (Al_2O_3,2 $S.O_2$, H_2O.) It is sometimes found in the mineral kingdom in varying conditions of purity. The mineral halloysite is of this nature, and the so-called Indianaite of Cox, having a composition represented by 45.90 per cent. of silica, 40.30 per cent. of alumina, 13.26 per cent. of water, with

0.198 per cent. of potash, 0.204 per cent. of soda, and traces of lime,* is of this character. In the pure state the silicate of alumina is highly refractory, being infusible before the blow-pipe, and practically fire-proof. It shrinks so much on drying, and especially when calcined, and is hence so liable to crack in the fire, that it cannot be made practically useful as a fire-clay until mixed with a considerable proportion of pure fine sand or ground burnt fire-clay. The admixture of fine sand does not sensibly reduce its refractory character, provided it is pure and free from fluxing materials, such as iron or manganese oxides, lime or magnesia, or the alkalies potash and soda, each of which substances increases the fusibility of the clay in which they are present. According to the experiments of Richter, in 1868, "the refractory quality of clays are least impaired by magnesia, more by lime, yet more by iron oxide, and most by potash." It is probable that soda is at least as active in this respect as potash, and the oxide of manganese more so than the oxide of iron. The phosphates also increase the fusibility of the clay.

The admixture of pure sand diminishes the plasticity and also the contractility of the clay on being dried or calcined, and increases its porosity. The same object is attained by mixing it with ground burnt fire-clay, plumbago, or ground coke or anthracite, and these substances are believed not to diminish the refractory quality of the clay. The well known Hessian crucibles or sand crucibles are an example. The Hessian crucible clay is composed of 71 per cent. of silica, 25 per cent. of alumina, 4 per cent. of iron oxide,† mixed with one third to one half its weight of quartz sand. It is said, however, that the quartz sand increases the fusibility of the clay when it is heated with fluxing materials, especially with oxide of lead, and that the substitution of ground burnt clay, of a pure kind, for the quartz sand, makes the crucible more refractory.

*See Ky. Geol. Repts., vol. IV, N. S., pp. 164–5.

†This quantity of oxide of iron no doubt decreased the refractory quality of the clay, but this influence is somewhat counteracted by the large proportion of silica in the clay, and by the sand. The proportions of lime and of the alkalies are not given; some are undoubtedly present in this clay.

The black lead crucible, so-called, made of clay mixed with plumbago, is less porous, and takes a smoother finish than the sand crucible, and is more durable and less liable to break; hence it is used in the fusion of the precious metals and steel. Fire-bricks, tiles for lining furnaces, &c., are also made of the most refractory clays, mixed with pure sand or ground burnt fire-clay.

For making the large crucibles or pots used for melting glass, in which process the material is not only exposed for a great length of time to a very high temperature in the furnace, but also to the influence of fluxes in the contained melted glass, clay of a peculiar character, called glass-pot clay, is largely imported into this country from Germany at a considerable expense, it having been somewhat purified in that country.

As may be seen in the foregoing tables, this clay, as compared with the general average composition of our fire-clays, contains more than the usual proportion of silica, viz: 71.686 per cent., including the fine sand, it being exceeded in this respect only by some of our Tertiary fire-clays, which contain 77.739 per cent. (In regard to this ingredient, silica or sand, something depends on its state of division or combination. In *combination* with the alumina it forms the tough, plastic basis of clay, but in the form of *sand*, the coarser it is the more it diminishes that toughness or plastic character. Sand, in a *very fine* powder, partakes of the plastic nature of clay on mixture with water.) This glass-pot clay contains only a medium proportion of alumina, viz: 21.30 per cent., and a comparatively small proportion of iron oxide, but more of this injurious ingredient than some of our Coal-measures fire-clays, and not much less than some of the Tertiary. It has, by comparison with our fire-clays, small quantities of lime, magnesia, and potash, resembling, in this respect, some of our Coal-measures and Tertiary clays; it also has only a very small proportion of soda.

In England they use their Stourbridge fire-clays for the preparation of their glass-pots, and the chemical composition

of these, as given by Knapp (*Chem. Tech.*, *v.* 2, *p.* 35), from analyses by Richardson, is as follows.

Silica (including fine sand?) from	61.15 to 68.05	per cent.
Alumina from	18.18 to 25.00	"
Oxide of iron from	1.10 to 5.10	"
Lime from	0 to 1.30	"
Magnesia from	n. e. .85	"
Water from	6.00 to 12.50	"

Alkalies, potash, and soda not given; probably as above = 1.90 per cent.

On examining the tables of the composition of our fire-clays, several may be seen which would most probably serve admirably for the construction of glass-pots, more especially if the same care be taken to prepare and purify them as is used in Europe.

In using clay for refractory pottery, fire-bricks, or tiles, &c., much depends on the preparation of the clay. It is laid up in heaps or ridges, fully exposed to the weather, for months. The water and oxygen of the atmosphere, and the influence of frost, disintegrates it and measurably washes and purifies it. By the combined influence of moisture, oxygen, and any organic matter which may be present, insoluble iron sulphides are converted into soluble sulphate, and insoluble iron peroxide changed to soluble iron bi-carbonate. Some of the lime and magnesia are also washed out by the rains as soluble bi-carbonates, and some of the residual potash and soda, which entered into the chemical constitution of the rocks from which the clays were originally derived by the process of prolonged weathering, will become separated by the same process, and washed out by water; and thus the clay becomes greatly improved in purity and in its refractory character. The washing part of the process is aided artificially, and thus also are the pebbles, fine or coarse sand, separated, more or less, as may be necessary, from the finer particles of the impalpable silicate of alumina. In the purification of some clays, the powdered and softened mass is mixed with impure water, containing organic matters, and allowed to ferment or rot in a warm atmosphere. The decomposing organic matters aid greatly in the separation of the mineral impurities, by bringing them into a soluble form, as detailed above, and thus facilitate their removal from the clay by subsequent washing with purer water.

For crucibles, glass-pots, fire-bricks, and tiles, very refractory clays alone can be used, containing as large a proportion of silica in the form of sand, more or less fine, or of ground burnt clay, as can be used without destroying the plasticity and adhesiveness of the mass, and the smallest possible proportions of potash or soda, lime, oxide of iron, or magnesia. The most refractory clays burn white, because of their very small proportion of iron oxide, which, when exceeding one to two per cent., begins to give a yellowish tint to the burnt clay, increasing in intensity and passing into various shades of orange, red, and brown, as the quantity increases, and proportionately increasing its fusibility. The best fire-clays should not contain more than from 0.2 to 0.5 per cent. of either lime, potash, soda, or magnesia; their fusibility increases as the proportions of these fluxing materials increase. For many of the ordinary uses of these clays, however, these proportions may be double, or treble in some cases, without detriment, where the heat to be resisted is not very intense.

But for the numerous uses of the potter, in the manufacture of the various products of the ceramic art; from the pure and highly artistic, richly decorated porcelain, the parian, wedgwood, stone-ware, delf, queen's-ware, majolica so-called, down to the simple red flower-crock or the common brick, clays less refractory and less pure are available. Even many of the marls, or marly clays, which would melt into a slag at a bright heat, or become deep colored, red or brownish-red by calcination, because of their large proportions of fluxing materials, including iron oxide, are employed; and it is a remarkable fact, demonstrated in the most ancient remains of human art, that whatever may have been the kind employed, articles made of clay, if they have been well burnt or calcined without fusion, withstand the influence of time and the atmospheric agencies better than any other building material known; while ancient granite, porphyry, and marbles, are found to be corroded more or less, the clay tablets of the most ancient peoples are measurably unchanged.

The pure white porcelain or china-ware is only to be made

of the primary clay called kaolin, derived from the decomposition of white felspar, mixed with a proper quantity of pure powdered quartz and undecomposed felspar, with sometimes a certain quantity of fluxing material, which causes it to soften somewhat or frit in the heat of the kiln. This softening or fritting, caused by the presence in the clay of lime, the alkalies, or other fluxing materials, also gives the compactness and solidity to the so-called "stone-ware." But the hardest and most refractory Berlin porcelain used in the chemical laboratory has a composition represented by silica 72.96 per cent., alumina 24.78 per cent., lime only 0.104 per cent., magnesia and iron only traces, and alkalies 1.22 per cent. The clay used at the Royal Porcelain Manufactory at Sèvres (Fr.), contains silica 58.0 per cent., alumina 34.5 per cent., lime 4.5 per cent., potash 3.0 per cent., being thus more plastic and more fusible than that used at Berlin. These wares are of considerable variety, and the glazing or more fusible glass or enamel with which they are coated in a second burning, penetrating the porous burnt clay, converts the whole into a homogeneous, compact, translucent material.

Potter's clays, as compared with fire-clay or porcelain clay, are generally more plastic and adhesive than those, because of their larger proportion of alumina. They are found in every condition of purity, but contain notable proportions of the fluxing materials. Plastic clays or potter's clays may vary in composition greatly: the silica from 42 to 70 per cent., the alumina from 20 to 40 per cent., the iron oxide from 1 to 15 per cent. or more, the lime from 0.5 to 5 per cent., the alkalies from 0.5 to 2 or 3 per cent., producing wares more or less refractory, firm, porous, and colored, and applicable not only in the highly artistic pottery and terra-cotta, so useful and durable in architectural ornamentation, but in the drain-pipes and tiles and the ordinary building bricks.

For all these purposes, except for the manufacture of fine porcelain ware, the clays of Kentucky are applicable, requiring only the hand of the skilled workman, and the proper use of capital, to make them profitable.

TABLE K.

AVERAGES OF THE COMPOSITION OF THE MARLS AND MARLY CLAYS AND MARLY SHALES OF THE SEVERAL GEOLOGICAL FORMATIONS OF KENTUCKY (*dried at 212° F.*)

	Silica.	Alumina.	Iron peroxide.	Lime.	Magnesia.	Phosphoric acid (P_2O_5).	Potash.	Soda.	Water and loss.
TERTIARY—MARL.									
Fulton Co. Vol. V, N. S, p. 432—No. 2142 (*a*)	68.860	12.980	2.240	9.587	1.182	n. e.	1.773	1.278	2.100
COAL-MEASURES—MARLY SHALES.									
Boyd Co. Vol. I, N. S., p. 160—No. 1292 (*b*)	†77.560	12.643		.269	.929	.217	*1.387	*.080	5.830
Carter Co. Vol. I, N. S., p. 180—No. 1343 (*a*)	66.060	23.726		.168	.060	.127	2.093	2.273	5.300
Union Co. Vol. 2, O. S., p. 267—No. 220 (*b*)	†32.670	6.700		28.486	.698	.280	.310	.166	n. e.
UPPER SUB-CARBONIFEROUS—MARLS, MARLY CLAYS AND SHALES.									
Breckinridge Co. Vol. 2, O. S., p. 138—No. 312 (*marly shale*) (*b*)	†78.680	12.170		.351	.413	.101	.556	.190	6.720
Grayson Co. Vol. IV, N. S., p. 70—Nos. 1788-93, inclusive (*average of 6 marly shales*), (*b*)	†61.190	22.863		c1.432	2.623	.495	*a*4.837	*a*.752	6.529
Grayson Co. Vol. I, N. S., p. 220—No. 1446 (*marly shale*) (*b*)	†71.580	19.133		.269	.353	.267	2.910	.052	6.230
Grayson Co. Vol. I, N. S., p. 220—No. 1446 (*same by fusion*) (*a*)	60.060	14.130	13.480	.538	1.158	.280	4.625	.783	6.000
Nelson Co. Vol. 3, O. S., pp. 358-9—Nos. 726 and 728 (*average of 2 marls*) (*b*)	†85.415	10.640		.346	1.249	.117	.703	.355	1.127
Nelson Co. Vol. 4, O. S., p. 238—Nos. 1189 and 1190 (*average of 2 marly clays*) (*a*)	53.480	14.154	9.840	4.021	.802	.671	2.107	.122	11.900
Average composition of the 3 analyzed by fusion (*a*)	55.670	14.145	11.053	2.860	.921	.540	2.950	.342	9.933

TABLE K.—AVERAGES OF THE COMPOSITION OF THE MARLS AND MARLY CLAYS AND MARLY SHALES OF THE SEVERAL GEOLOGICAL FORMATIONS OF KENTUCKY—Continued.

	Silica.	Alumina.	Iron peroxide.	Lime.	Magnesia.	Phosphoric acid (P_2O_5).	Potash.	Soda.	Water and loss.
LOWER SUB-CARBONIFEROUS—WAVERLY.									
Jefferson Co. Vol. V, N. S., p. 444—Nos. 2166–7 (*average of 2 marly shales*) (*a*)	60.370	20.340		1.674	1.058	n. e.	4.678	.649	6.230
Meade Co. Vol. V, N. S., p. 224—No. 2066 (*under clay*) (*b*),	†82.125	11.604		.025	.538	.156	1.082	n. e.	.650
Nelson Co. Vol. V, N. S., p. 461—No. 2216 (*marly clay* (*a*),	61.100	24.200		4.904	1.542	n. e.	4.101	.821	3.332
Average composition of the 3 analyzed by fusion, &c. (*a*),	60.607	21.637		2.751	1.219	n. e.	4.486	.706	5.197
BLACK SLATE ("OHIO SHALE") FORMATION.									
Madison Co. Vol. 4, O. S., p. 212- No. 1124 (*the "Devonian Shale"*) (*b*)	63.120	8.560		6.261	2.034	.143	1.363	n. e.	*d*12.00
"CRAB ORCHARD SHALE" (CLINTON SHALE?)									
Madison Co. Vol. V, N. S., p. 446—Nos. 2186–7 (*average of 2 marly shales*) (*a*)	45.540	19.080	3.680	10.637	.479	n. e.	3.573	.295	n. e.
UPPER SILURIAN FORMATION.									
Jefferson Co. Vol. 4, O. S., p. 192—No. 1069 (*marly shale*) (*a*)	59.900	7.260		15.053	.803	.694	.965	.012	2.196
UPPER HUDSON FORMATION.									
Henry Co. Vol. I, N. S., p. 265—No. 1577 (*indurated marl*) (*a*)	23.700	7.146	11.040	24.954	.310	1.164	2.100	.623	8.396
Jefferson Co. Vol. V, N. S., p. 444—No. 2165 (*marly shale*) (*a*)	47.960	*g*21.340	6.600	5.824	3.524	n. e.	5.264	.250	9.238
Average composition of the 2 Upper Hudson marls (*a*)	35.830	14.243	8.620	15.189	1.917	n. e.	3.682	.436	8.567

Middle Hudson Formation.								
Grant Co. Vol. 4, O. S., pp. 158-9—No. 990 (*marly shale*) (*b*)	†71.280	16.250	2.789	1.564	.310	.988	.178	1.532
Grant Co. Vol. 4, O. S. pp. 158-9—No. 991 (*marly shale*) (*b*)	†78.480	12.340	1.557	.574	.630	.957	trace.	3.074
Grant Co. Vol. V, N. S., p. 198—No. 2114 (*under clay*) (*b*)	†75.240	15.273	1.282	.383	.823	h1.124	.019	4.950
Grant Co. Vol. V, N. S., p. 199—No. 2117 (*under clay*) (*b*)	†60.967	27.353	2.551	.266	.457	i1.585	.125	4.675
Owen Co. Vol. 4, O. S., p. 244—No. 1203 (*marly shale*) (*b*)	†29.240	19.940	19.365	2.518	.934	.649	0	8.998
Average composition of the 5 marly shales (*b*)	63.041	18.231	5.508	1.061	.631	1.061	.064	4.409
Lower Hudson Formation.								
Campbell Co. Vol. I, N. S., p. 171—Nos. 1317-8 (*average of 2 marly shales*) (*a*)	54.750	30.470	2.103	1.195	.189	3.584	.776	4.550
Campbell Co. Vol. I, N. S., p. 178—Nos. 1335-6 (*average of 2 marly shales*) (*a*)	55.710	14.527 | 13.525	3.461	.472	.145	3.884	.999	4.114
Fleming Co. Vol. 4, O. S., p. 150—No. 972 (*marly clay*) (*a*)	39.780	10.401 | 10.760	9.453	6.385	.079	1.147	n. e.	13.900
Franklin Co. Vol. I, N. S., p. 212—No. 1434 (*marly shale*) (*a*)	52.060	18.831 | 9.200	3.666	1.210	.319	5.402	.720	7.672
Kenton Co. Vol. I, N. S., p. 270—Nos. 1585-6 (*average of 2 marly shales*) (*a*)	45.310	21.920	13.210	.760	.367	2.374	1.252	4.530
Mason Co. Vol. 4, O. S., p. 216—No. 1130 (*marl*) (*b*)	†78.180	8.020	4.133	3.105	1.040	.722	.170	.791
Average composition of the 8 marls, &c. (excluding No. 1130), (*a*)	50.422	26.035	7.582	1.556	.225	3.279	.957	5.996
Trenton Formation.								
Fayette Co. Vol. 2, O. S., p. 160—Nos. 509-10 (*average of 2 under clays*) (*b*)	†73.434	19.753	.367	.230	.407	.309	.121	n. e.
Fayette Co. Vol. V, N. S., p. 422 No. 2120 (*marly clay*) (*a*)	53.780	23.260 | 1.300	4.866	.568	.191	7.612	.550	7.873

TABLE K.—AVERAGES OF THE COMPOSITION OF THE MARLS AND MARLY CLAYS AND MARLY SHALES OF THE SEVERAL GEOLOGICAL FORMATIONS OF KENTUCKY—Continued.

	Silica.	Alumina.	Iron peroxide.	Lime.	Magnesia.	Phosphoric acid (P_2O_5).	Potash.	Soda.	Water and loss.
BIRDSEYE FORMATION.									
Franklin Co. Vol. I, N. S., p. 211-12—Nos. 1431-2 (*average of 2 marly shales*) (*b*)	†73.720	12.905		.841	1.548	.447	*f*3.526	.180	5.875
Franklin Co. Vol. I, N. S., p. 213—No. 1433 (*marly shale*) (*a*)	50.860	16.816	6.997	8.736	.936	.217	3.623	1.730	8.309

† Silica and insoluble silicates.
a Analyzed by fusion.
b Analyzed by acids.
c Equal to 2.557 per cent. lime carbonate.
d Water and bituminous matters.
e No. 2183 contains 19.285 per cent. of gypsum.
f Total average potash by fusion equals 7.804 per cent.
g Including the phosphoric acid.
h Total potash obtained by fusion, &c., equals 3.534 per cent.
i Total potash obtained by fusion, &c., equals 3.072 per cent.
* Analyzed by fusion with $CaCl_2$ and NH_4Cl it gave 3.989 per cent. of potash and .639 per cent. of soda.

TABLE L.

GENERAL AVERAGES OF THE COMPOSITION OF THE MARLS, MARLY CLAYS, AND MARLY SHALES OF THE SEVERAL GEOLOGICAL FORMATIONS OF KENTUCKY (*dried at 212° F.*)

	Silica.	Alumina.	Iron peroxide.	Lime.	Magnesia.	Phosphoric acid (P_2O_5).	Potash.	Soda.	Water and loss.
Composition of 1 Tertiary marl (*a*)	68.860	12.980	2.240	9.587	1.182	n. e.	1.773	1.278	2.100
Composition of 1 Coal-measures marly shale (*a*)	66.060	23.726		.168	.060	.127	2.093	2.273	5.300
Average composition of 2 Coal-measures marly shales (*b*),	†55.115	9.671		14.377	.813	.249	.849	.123	n. e.
General average of 3 Upper Sub-carboniferous marly shales, &c., (*a*)	55.670	14.145	11.051	2.860	.921	.540	2.950	.342	9.933
General average of 3 Lower Sub-carboniferous marly shales, &c., (*a*)	60.607	21.637		2.751	1.219	n. e.	4.486	.706	5.197
Composition of 1 Black Slate shale (*b*)	63.120	8.560		6.261	2.034	.143	1.363	n. e.	*d*12.000
General average of 2 Clinton shale marly shales, &c., (*a*),	45.540	19.080	3.680	10.637	.479	n. e.	3.573	.295	n. e.
Composition of 1 Upper Silurian marly shale, &c., (*a*)	59.900	7.260		15.053	.803	.694	.965	.012	2.196
General average of 2 Upper Hudson marly shales, &c., (*a*),	35.830	14.243	8.620	15.189	1.917	n. e.	3.682	.436	8.567
General average of 5 Middle Hudson marly shales, &c., (*b*)	63 041	18.231		5.508	1.061	.631	1.061	.064	4.409
General average of 8 Lower Hudson marly shales, &c., (*a*),	50.422	26.035		7.582	1.556	.225	3.279	.957	5.996
Composition of 1 Trenton marly clay (*a*)	53.780	23.260	1.300	4.866	.568	.191	7.612	.550	7.873
Composition of 1 Birdseye marly shale (*a*)	50.360	16.816	6.997	8.736	.936	.217	3.623	1.730	8.309

† Silica and insoluble silicates. *a* Analyzed by fusion, &c *b* Analyzed by digestion in acids, &c. *d* Water and bituminous matters.

The number of these marls and marly clays, &c., which have been brought into comparison, viz: thirty from eleven different groups, is too small to show the influence of the several geological formations on their composition. So far as these go, they show the Tertiary, Coal-measures, and Middle Hudson marls to be the most silicious; the Upper Hudson, Upper Silurian, Clinton, Coal-measures, Tertiary, Birdseye, and Lower Hudson marls contain the most lime; those from the Upper Silurian, Middle Hudson, and Upper Sub-carboniferous groups contain the most phosphoric acid; those from the Trenton, Lower Sub-carboniferous, Upper Hudson, Birdseye, Clinton, and Lower Hudson groups are richest in combined potash; and soda is in largest proportions in the marls from the Coal-measures, Birdseye, Tertiary, and Lower Hudson groups.

Marls are impure clays of variable composition, generally containing a considerable proportion of carbonate of lime. They pass, on the one hand, into clays proper; on the other, into limestones; while they may shade into iron ores as their variable proportions of iron oxide increase. They are usually, even when in the hardened state of shale, readily disintegrated by exposure to the atmospheric agencies. The earliest use made of them was on the soil to increase its fertility, which it was supposed to do mainly by supplying lime where it was deficient, or by altering the consistence of the soil when too compact and heavy, or too sandy and light. For such uses the question of the cost of transporting and applying the large quantity required to alter the physical character of a soil is a serious one, and hence the modern use of marls is mainly restricted to those which contain much lime, or which are found to have much potash or phosphoric acid in their composition.

It is found, however, that the potash and phosphoric acid, although contained in some of these marls in notable proportions, are not readily or quickly available as elements of plant nourishment; the former being probably in firm combination with the silicate of alumina, and the latter forming insoluble phosphates of iron and alumina. So that, like a subsoil or

under-clay, in which chemical analysis demonstrates the presence of considerable proportions of these essential materials, they prove at first less suitable to vegetable growth than the more porous surface-soil, which contains less potash or phosphoric acid, but which is darker colored by the humus which it contains.

In the course of time, by the action of the atmospheric elements and of the humic acids derived from the decay of the vegetable matters on the surface, or more quickly by admixture with stable manure, the potash and phosphates of the sterile subsoil, marl, or under clay are brought into a condition available for vegetable nourishment, and the partly exhausted surface-soil is renovated by the admixture. Gardeners and farmers have found by experience that the gradual mixture of marls, or heavy marl-like subsoils, together with the use of materials to furnish humus, is the best practical mode of making them useful in renovating the exhausted surface-soil.

This result of the experience of the practical farmer shows, no doubt, how these marls may be most profitably used. It is said by some observers that admixture of caustic lime with the marls will aid in the separation of the potash and phosphoric acid; and it is known that to calcine them in mixture with lime or carbonate of lime and calcium chloride, such as is abundantly thrown away in the bitter water which drains off from salt at the salt-works, will fully liberate the potash; but this is unavailable on a large scale because of its cost, and consequently, it appears that the best probable method of using these rich marly clays, marls, or subsoils on the exhausted soil, is to spread them on the surface, mixed preferably with slaked lime, and then to sow the land with clover, which, after a year or two of growth and pasturage, will supply to the soil, when plowed in, a large amount of vegetable matter to form humus, which will greatly aid in the chemical decomposition of the marl, and in improving the productiveness of the soil.

As may be inferred from their composition, some of these Kentucky marly clays may be employed in making some forms of pottery, terra-cotta, &c., especially the so-called stone-ware, which is hard and compact because of the softening or partial fusion of the clay in the heat of the kiln, and which is glazed with common salt only. For the various forms of *terra-cotta*, and architectural appliances and ornaments, the tints which some of these clays assume on burning would make them more appropriate. Ground and calcined with a proper proportion of lime, several of these marly clays, especially those containing much alkali, would no doubt make good Portland cement, the most durable of water cements; used in large structures, mixed with more or less sand, gravel, and pebbles, &c., as the *Bèton* of the French.

When the oxide of iron is in large proportion in a hydrated state, these clays may be advantageously employed as materials for painting, as pigments of various tints of yellow, orange, red, and brown, having the names of boles, ochres, red chalk, terra sienna, umber, &c., &c. These, when calcined, assume other colors—the yellows changing to reds, &c., &c. They are among the cheapest and most durable of common pigments. The published Kentucky Geological Reports give several examples of such ferruginous clays.

GEOLOGICAL SURVEY OF KENTUCKY.

JOHN R. PROCTER, DIRECTOR.

CHEMICAL REPORT

OF THE

Soils, Coals, Ores, Clays, Marls, Iron, Slags, Mineral Waters, Rocks, Etc.,

OF KENTUCKY.

BY ROBERT PETER, M. D., ETC., ETC.,

CHEMIST TO THE SURVEY,

ASSISTED BY ALFRED M. PETER, S. M.

The fifth Report in the New Series, and the ninth since the beginning of the Geological Survey.

JOHN D. WOODS, PUBLIC PRINTER AND BINDER.

INTRODUCTORY NOTE.

CHEMICAL LABORATORY OF KENTUCKY GEOLOGICAL SURVEY,
STATE A. AND M. COLLEGE, LEXINGTON, Dec., 1883.

JOHN R. PROCTER, *Director of Kentucky Geological Survey:*

DEAR SIR: Herewith I respectfully submit to you the report of the chemical work performed in this laboratory for the Geological Survey since the publication of my last report.

Yours, etc., ROBERT PETER.

CHEMICAL REPORT.

In the present report the results are given of more than two hundred chemical analyses. There are of

Soils and subsoils	16
Coals	112
Cokes	19
Mineral waters	26
Limestones	19
Sandstones	2
Clays	2
Iron ores	15
Pig irons and slags	4
Marls, ochre, coprolite	8
Total	218

The SOILS AND SUBSOILS are from four counties only, viz.: Morgan, Nelson, Shelby, and Spencer, representing, respectively, coal measures, upper silurian, and upper Hudson river formation soils.

The six coal-measures soils from Morgan county, with the exception of the virgin woodland soils, do not probably represent the best average soil of that region, having been collected on the water-shed of the Licking river, where they have been subjected to the leaching action of the atmospheric waters, or on the bottom land bordering the stream. But they all may be profitably cultivated under favorable conditions. It will be seen that the subsoil contains less carbonate of lime than the surface soil, also less of rocky fragments, and the old-field soils show in every case a dimunition of the essential elements of fertility as the result of continued cultivation.

The Shelby county soils, except No. 2436, which is on the upper silurian formation, are located on the upper Hudson river beds. Nos. 2430, 2431, and 3432 contain more than the average proportions of all the essential elements of fertility, and less than the average of sand and silicates, and should therefore be quite fertile under favorable conditions. Numbers

2433 and 2435 are remarkable for their large proportions of organic and volatile matters, alumina, etc., etc., and especially of carbonate of lime, No. 2435 containing as much as 25.245 per cent. of that ingredient, constituting it a kind of marl, and No. 2433 contains 4.695 per cent. more than has been observed in any other Kentucky soil heretofore analyzed. Their proportions of potash, extracted by acids, is also exceptionally large, being 2.015 per cent. in No. 2433 and 1.772 per cent. in No. 2435. They also contain much less than the usual quantity of sand and insoluble silicates, these being in the proportion of 61.045 per cent. in the former and only 47.295 in the latter soil. The former contains 8.2 per cent. of fragments of calcareous fossils and rock fragments, and the latter, which is a subsoil, as much as 41.2 per cent., and should be discounted in these proportions.

A certain small quantity of lime in the soil is essential to productiveness, as this substance is an indispensable element of all vegetable structures, and the influence of very large proportions of carbonate of lime on the soil has been ascertained to a certain extent by practical experiment and observation.

Applied in quantity to a heavy, wet, clay soil, lime, which soon becomes carbonate, makes it more light and friable, lessens its tendency to shrink and swell in dry and wet seasons, and allows water to evaporate from it more freely. But when the carbonate of lime is in too large proportion, untempered by clay, it forms a soil which parts with its water too readily, and becomes so light in times of drought that its surface may be blown away by the wind, conditions unfavorable to vegetation. The chemical relations of carbonate of lime are quite important. In contact with the insoluble silicates of the soil, it favors their decomposition, setting free, in a soluble form, their potash, soda, phosphoric acid, etc. It also greatly aids the decomposition, in the moist soil, of the organic matters present, causing the more rapid formation of carbonic acid and water and favoring the production of ammonia and nitrates—all essential food of plants. It also has the valuable property of absorbing and holding for the nourishment of vegetation, organic matters, ammonia, and other nitrogen compounds, and the phosphoric acid, which may

be in the air or water which penetrate the soil. Within proper limits, therefore, this ingredient of soils is very valuable, and the farmers of England especially, habitually apply it to their cultivated soils.

The old-field soil, No. 2434, from the same locality as these two calcareous soils, is remarkable for containing much smaller proportions of carbonate of lime and of the other essential ingredients than those, although it contains more than average quantities. It differs from them greatly also in its 83.31 per cent. of sand and insoluble silicates, and in containing no calcareous fossils or rock fragments, seeming to show that, although on the same farm, it may be located on a different geological substratum or bed.

The two Spencer county soils, soil and subsoil, from a very old field located on the upper Hudson river beds, yet retain full average proportions of the essential elements, organic matters, or *humus*, excepted. The surface soil contains more than average sand and silicates and phosphoric acid, less than average proportions of organic matters and potash, and about averages of alumina, lime, and magnesia. The subsoil contains more than average proportions of alumina, etc., phosphoric acid and potash, less than average of organic matters and sand and silicates, and about average lime and magnesia. Its proportion of potash is much above the average, and in both organic matters are quite deficient.

More than twenty years ago the late Prof. Liebig, then as now an "authority" on agricultural chemistry, promulgated his opinion, based, as we believe, on imperfect data, that the chemical analysis of soils is of no practical value. At once all the authors at second-hand took up the cry, and to this day copyists and others who have no taste for this kind of investigation, or who had not been trained to appreciate the value of its indications, while in accordance with the progress of agricultural chemistry they are obliged to attach great importance to the presence or absence of certain elements of fertility in soils, still keep up an inconsistent opposition to this mode of interrogating nature in aid of agriculture. One principal argument used by

these objectors is that the acid solvents used by the chemists in their analyses differ from the natural agents of solution by which the soil elements are made available for plant growth. But Liebig himself measurably destroyed the force of this objection when he called attention to the fact that plants do not derive their soil ingredients from the so-called "soil water" alone, but exert, through their rootlets, a direct solvent action on the particles of the soil; and the solvent is proved to be an acid one. The present writer, in experiments detailed in a previous report, proved that strong acids, such as oxalic and phosphoric acids,* enter into the composition of this peculiar solvent or digestive fluid of plants, by means of which solid ingredients of the soil are dissolved and made available for their nourishment and growth.

Time and experience have gradually set aside most of the objections which were made to this mode of studying the character and value of soils, and in a new country no other method is known by which the capabilities of the virgin soil can be so cheaply, speedily and certainly estimated. More especially is this true in Kentucky, where the soils have mostly been formed in place by the disintegration of the subjacent rocks, and not of transported materials.

We may briefly recapitulate some of the peculiar uses of soil analysis:

1. To teach the natural capabilities of the soil; its present probable fertility and durability under existing conditions.

2. To detect elements or conditions injurious to plant growth, and point out available remedies.

3. To show any surplus or deficiency of essential elements, and indicate the best remedies—fertilizers or mechanical agencies.

A good analysis of the soil of a homogeneous field may be beneficial for ages, if properly understood and judiciously taken as a guide in culture and the application of fertilizers.

A good exemplification of these facts appeared in a letter from Charles Bernard to the New York *Evening Post*, in 1871, giving an account of the extraordinary farming operations of

*See Vol. V., Ky. Geological Reports, N. S., pp. 239, 244.

Mr. John Prout, of London, on a worn-out clay farm of four hundred and fifty acres, near the town of Sawbridgeworth, in Hertford county, which were then making quite a stir in England. With underdraining, deep plowing, and the use of chemical fertilizers, bone-dust, superphosphates, etc., etc., without any barn-yard manure, he soon caused the unproductive soil to bear the largest crops ever known in the country.

To obtain this high and profitable improvement, Mr. Prout kept a chemist constantly employed on his farm, who reported regularly the composition of the soil of each field, and directed and superintended the application of the chemicals and fertilizers to make and keep the land fertile and productive. And Mr. Bernard reported the standing crops, which he personally examined, on the several fields to be, "without exception, of most extraordinary vigor and abundance." But the most remarkable novelty of Mr. Prout's management was that as the crops ripened they were all sold at auction and entirely removed by the purchasers from the ground, "so that the harvesting and marketing occupy one day." This plan was successfully continued year after year, and Mr. Prout's books showed a greater net profit than was obtained by any farmer in the country, although he expended $5,750 a year for fertilizers alone. Late reports, if the writer is not misinformed, stated that he was yet successfully carrying out this improved agriculture.

The one hundred and twelve Kentucky COALS analyzed, which are here reported, are from eighteen counties, viz.: Bell, Breathitt, Carter, Elliott, Floyd, Johnson, Knox, Laurel, Lawrence, Letcher, Magoffin, Martin, Morgan, Muhlenberg, Perry, Pike, Pulaski, and Whitley.

For comparison with our Kentucky coals, three samples each from Alabama and Tennessee and one from West Virginia were collected and analyzed, and the analyses of four celebrated Pennsylvania coking coals made by the chemist of the Geological Survey of that State are copied.

Of the samples of Kentucky coals, eighteen were of cannel coals. Of these the *average volatile combustible matters*, including No. 2291, (which, having as much as 20.60 per cent. of ash,

might probably be excluded as belonging rather to the bituminous shales than coals,) was 46.32 per cent. The average *ash* percentage of the *cannel coals* examined, excluding No. 2291, was 9.36; varying from 2.20 per cent. in No. 2369, Letcher county, to 19.50 in No. 2381, of Morgan county. It will be seen by reference to the table that several of the Kentucky cannel coals are more than equal in gas-making or gas-improving power, to the cannel coal of West Virginia, which is much used for that purpose.

The *specific gravity* of the coals, here reported, varies from 1.191 in No. 2354, of Letcher, with an *ash* percentage of only 2.60, to 1.634 in No. 2286, in Carter, with an *ash* percentage of 40.00. This latter, however, should more properly be called a bituminous shale than a coal. It is proposed to draw the line between these shales and coals proper on the ash percentage of 20.00, giving the name shale to all which have a greater percentage than this.

The *volatile combustible matters* of these coals (excluding the cannel coals) varies from 22.70 per cent. in No. 2346, from Letcher, which had an ash percentage of 9.54, to 40.90 per cent. in No. 2354, of Letcher, which had an ash percentage of only 2.60.

The *fixed carbon* in the coke varied from 33.76 per cent. in No. 2381, of Morgan county, to 67.60 per cent. in No. 2404, of Pike.

The *sulphur* varied from 4.527 per cent. in No. 2385, from Morgan county, to 0.390 per cent. in No. 2405, of Pike county.

Those coals which have the largest proportion of fixed carbon with the smallest percentage of sulphur are the best fitted for coking purposes, provided they have enough volatile combustible matters to cause them to soften and become porous in coking, and to afford heat enough by their combustion to effect the process without burning fixed carbon.

Cannel coals do not make good coke for the iron-smelting furnace, because, although they give more volatile combustible matter than most other coals, they do not soften much or become porous in coking. The so-called bituminous or soft coals, gen-

erally soften and swell too much for this use, and their coke consequently will not support the burden in the high furnace.

But the so-called splint, or semi-cannel coal, known in Indiana as "block coal," of which variety there is a vast quantity in Kentucky, characterized by its laminated structure and firm consistence, softens and swells less than the soft bituminous coal when exposed to heat, becoming a dense, firm coke with small pores, and consequently it is largely used without coking in the smelting of iron.

The softer and purer varieties of this coal, such as are found in Pike and other counties, are admirably adapted to the production of good coke, which compares most favorably with the best and most celebrated cokes of Pennsylvania. (See context, Bell and Pike counties, and Table II.)

Cannel coal, when heated, gives off without softening much combustible gas, which burns with a clear, luminous flame, from which it derived its name—cannel (Scotch) or candle coal. It owes this peculiar property to the fact that it contains oxygen in large proportion to its hydrogen and carbon. The soft bituminous coal, on the other hand, contains but little oxygen; its gas, mainly composed of hydro-carbons, burns with a more smoky flame, and it appproaches in physical properties the "bitumens" proper.

Anthracite coal is not to be found in Kentucky. This contains little or no volatile combustible matter, being mainly carbon and of the nature of a dense, compact coke. The Broad Top coking coal of Pennsylvania approaches anthracite in its large percentage of fixed carbon. (See Table III, and under Pike county.)

In the analysis of coals much depends on the collection of *average samples* of the bed. This has been carefully done in most cases, and in some samples of the several benches or layers have been separately collected and analyzed.

Of the nineteen cokes which have been analyzed, sixteen are from eight counties in Kentucky, and two are of the Jellico Mountain Coal and Coke Company's coke. The analysis of the celebrated Connellsville coke of Pennsylvania is copied from the Special Report L, of the second Pennsylvania Geological Survey.

The average percentage of *fixed carbon* in the sixteen Kentucky cokes is 90.61, including the very impure coke, No. 2326, of Hopkins county, which was made of unwashed impure slack coal; or, excluding this very exceptional sample, the fixed carbon average is 91.105 per cent., even when another very impure sample, No. 2325, from the same locality, is included; ranging from 77.20 per cent. in No. 2326, up to 95.70 per cent. in No. 2342, of Laurel county.

The *ash* percentage averages 7.44 per cent., including No. 2326, and 6.60 per cent. when this very impure coke is excluded; ranging from only 2.60 per cent. in No. 2449, of Whitley county, up to 13.80 per cent. in No. 2325, of Hopkins county, while it is 20.80 per cent. in the excluded sample, No. 2326.

The percentage of *sulphur* in these Kentucky cokes is 1.088 per cent., including the very impure No. 2326, or 0.907 per cent. when this sample is excluded; ranging from only 0.517 in No. 2414, of Pike county, up to 3.799 in No. 2326, of Hopkins county, above described.

Table III shows, however, that so far as chemical composition is concerned all of the Kentucky cokes reported, with two or three exceptions only, equal or excel the celebrated Connellsville coke of Pennsylvania, and there is no doubt that Kentucky possesses a large area of coal which is eminently fitted for the smelting of iron ores, either in the coked or uncoked condition.

Of the fourteen *iron ores* reported from Greenup, Johnson, and Pike counties, nothing especially new is to be stated. Numbers 2309, 2310, 2312, and 2316 contain a fair proportion of manganese, but not enough to make them available for the manufacture of *spiegeleisen*, used in the Bessemer steel process. In this connection, however, attention is called to a sample sent to the Chemical Laboratory of the Kentucky Geological Survey for analysis, in 1858 or 1859, by Messrs. Lampton, Nicholl & Co., the proprietors of Star Furnace, Carter county, labeled by them No. 6 and designated as "black ore," which on analysis was found to contain manganese equivalent to 39.677 per cent. of its brown oxide. (See Vol. 4, O. S., Kentucky Geological Reports, pp. 106-7, No. 862.) It is described as a "dark-col-

ored, friable ore; a nodular mass, with a soft brownish-yellow nucleus." If this ore is abundant it might be made useful in the manufacture of Bessemer steel.

The nineteen *limestones* described are from seven counties, viz.: Carter, Fayette, Franklin, Mercer, Nelson, Shelby, and Spencer; from the coal measures, upper silurian, chazy, upper Hudson, and Trenton formations. They vary greatly in their composition, as may be seen in the following comparative statement. Of the eleven samples of phosphatic limestone from the Trenton (lower silurian) formation of Fayette county, only their relative proportion of phosphoric acid was estimated. In the other eight different limestones:

The Carbonate of Lime ranged

From 96.380 per cent. in No. 2290, coal-measures limestone, of Carter county,
To 40.780 per cent. in No. 2437, upper silurian, ... of Shelby county.

The Carbonate of Magnesia ranged

From 80.720 per cent. in No. 2378, chazy limestone, ... of Mercer county,
To 1.185 per cent. in No. 2290, coal-measures limestone, . of Carter county.

The Alumina and Iron Oxide, etc., ranged

From 10.550 per cent. in No. 2379, chazy limestone, ... of Mercer county,
To .980 per cent. in No. 2290, coal-measures limestone, . of Carter county.

The Phosphoric Acid in the Nineteen ranged

From 11.650 per cent. in No. 2292–3, Trenton limestone, . . of Fayette county,
To a trace . . . . . in No. 2290, coal-measures limestone . of Carter county.

And the Silicious Residue in the Eight ranged

From 25.520 per cent. in No. 2437, upper silurian, ... of Nelson county,
To .380 per cent. in No. 2290, coal-measures limestone, . of Carter county.

The alkalies, potash, and soda were determined only in the three limestones from Nelson and Spencer counties, all three from the upper Hudson river beds. The potash in the Nelson county limestones is severally 0.423 and 0.443 per cent., and the soda 0.248 and 0.254 per cent. In that of Spencer county they exist in the proportions of 0.154 per cent. of potash and 0.212 of soda. In this limestone the phosphoric acid is equal to 1.842 per cent.; in that from Franklin county (lower Trenton) the phosphoric acid is 2.968 per cent., and in No. 2394, Nelson county, it is 1.202 per cent.

It will be seen that the coal-measures limestone is a remarkably pure carbonate of lime, which would give nearly 54 per cent. of pure, white quick-lime, containing but little magnesia, alumina, and iron oxide, manganese and silica. The limestones,

No. 2395 and 2437, from Nelson and Shelby counties, would probably yield good hydraulic cements, and those which have a large proportion of phosphoric acid are well fitted for improvement of soils, as well as for all the ordinary uses of lime or limestones.

Of the twenty-six *mineral waters* examined, only twenty were submitted to quantitative analysis; and as these were analyzed in samples sent to the laboratory in bottles, etc., the proportions of the gases in them could not be determined with accuracy. Five, from Anderson, Boyle, and Ohio counties, are *sulphur waters*, so-called from the presence in them of hydrogen sulphide gas, and as in the case with No. 2262, of Anderson county, a small proportion of sodium sulphide. Five, all from Boyle county, are *chalybeate waters*, so-called because they contain a notable quantity of compounds of iron, and ten, from Bell, Boyle, Kenton, and Logan counties, are denominated *saline waters*, from the predominance of alkaline and earthy salts in the composition of their saline materials.

The *sulphur waters* vary considerably in their saline contents, some of them, such as Nos. 2274, 2275, and 2276, are called "black sulphur waters," from the circumstance that the iron carbonate, which they contain in notable proportions, varying in the several springs, undergoes decomposition, together with the hydrogen sulphide gas, when the water is exposed to the atmosphere, and the sulphur of the gas uniting with the iron of the carbonate produce a black sulphide of iron, which forms the deposit from which the water takes its name. The black sulphur waters, which should be used only fresh at the spring, are always somewhat chalybeate. The Boyle county sulphur waters, with the exception of No. 2275, which is simply a chalybeate sulphur water, contain enough saline matters to make them slightly aperient, especially No. 2276. In this respect No. 2379, from Ohio county, resembles them, but it contains much more sulphate of lime. The sulphur water from Anderson county, No. 2262, exceeds them all in its proportion of saline matter, mostly sodium chloride—common salt—and is a stronger and more durable sulphur water because of its sodium sulphide. In this

respect it resembles the celebrated Blue Lick water. It, like most of the others, contains traces of bromine, lithia, etc. The Boyle county sulphur waters are also slightly alkaline, from the presence of carbonate of soda. This is especially the case with black sulphur, No. 2274, which may therefore be more diuretic than the others. No. 2276 comes nearest to it in this respect.

The five *chalybeate waters* are all from Boyle county. They are of two kinds, those which contain bi-carbonate of iron, such as Nos. 2269, 2271, and 2272, and those which contain sulphate of iron, viz.: Nos. 2270 and 2273. The latter, having 10.485 per thousand of saline matters, contains as much as 2.6761 of sulphate of iron and 5.3477 per thousand of sulphate of alumina. It is more properly to be called an *alum* water than a chalybeate, and is too strong in these salts to be commonly used internally. It also, like No. 2270, is acid from the presence of free suphuric acid. The safest chalybeates are those which contain the iron in the form of bi-carbonate, which is the case with Nos. 2269, 2271, and 2272; of these the first named is the weakest. On exposure of these waters to the air, the bi-carbonate of iron, which is held in solution in the carbonated water, is changed into insoluble hydrated peroxide of iron, which falls as a brownish or reddish sediment. Hence such water should always be drank fresh from the spring, unless care is taken to exclude the air perfectly by inclosing it, without much agitation, in bottles with tightly-fitting glass stoppers.

The ten *saline waters*, from Bell, Boyle, Kenton, and Logan counties, may be divided into *chloride* and *sulphate* water. No. 2280 (*a*) is the only one which comes under the first division, and is simply a weak salt water, containing 13.878 per thousand of sodium chloride—common salt—the remainder of its 19.200 of total saline matters is composed of carbonates of lime and magnesia, and sulphates of potash, lime, and magnesia, with traces of lithia and strontia. The other nine saline waters mostly contain sulphates of lime, magnesia, potash, and soda, with a small proportion of chlorides, and carbonates of lime, magnesia, soda, and iron, all in variable proportions. Some, as No. 2263, from Bell county, and No. 2277, from Boyle county, contain so little

saline matters—0.1077 and 0.1021 severally—in a thousand parts of the water, that they can not properly be included under the head of mineral waters, they being remarkably pure potable waters. No. 2280 (*a*), with its 0.686 of *total saline* matters, comes very nearly under the same classification.

According to recent reports of the influence of potable waters upon the health of communities,* a certain amount of saline matter in the water is useful and necessary to health, provided these mineral substances have representatives in the animal economy, which is the case with lime, magnesia, iron, potash, soda, sulphuric acid, phosphoric acid, chlorine, etc., etc.; but if the potable water is too pure—too free from these wholesome saline matters—"the health of the community using it suffers." The recognized healthy proportion of such saline matters "does not exceed 0.500 in the thousand of water, nor fall below 0.130 to the thousand." It is evident, however, that this statement would not apply in all localities.

Notwithstanding these facts it is well known that some of the most celebrated waters in the world—widely known from their great curative action in many cases of disease—are found to be, on analysis, like Nos. 2263 and 2277, *nearly pure water;* and the demonstration is thus given that in certain conditions of the animal economy, where a depurative remedy is necessary or appropriate, the free use of pure water becomes a good curative agency when applied with discretion.

The remainder of these saline waters contain sulphates of lime, magnesia, potash, and soda, etc., in sufficient quantities to make them laxative in their action. Some, as Nos. 2280, 2278, and 2263, contain some carbonate of soda. All have a small quantity of carbonate of iron, especially No. 2371, of Logan county, which has 0.326 of this material, making it notably chalybeate, and No. 2278, of Boyle, which contains 0.102 per thousand.

Under the head of Boyle county is the description of certain coprolites, No. 2281, found at the base of the Waverley beds,

* See article "*Eaux Potables,*" par A. Gautier. (*Wurtz: Dictionnaire de Chemie, etc.* T. 1 Part. 2. p. 1200.)

which gave on analysis as much as 29.1 per cent. of phosphoric anhydride (P_2O_5). Under that of Floyd county, No. 2304, are described certain other phosphatic concretions, of irregular conical and somewhat spiral forms, probably coprolites, which are found in apparently a more recent clay, which have the property of changing from their original light-grey to a grey-blue color on exposure to the atmosphere—which gave as much as 8 per cent. of phosphoric anhydride.

A sandstone, No. 2393, from Nelson county, Boston district, collected by Mr. Linney in the black Devonian slate formation, very full of fossil relics of fishes, etc., gave on analysis 11.162 per cent. of phosphoric anhydride—equivalent to 24.372 per cent. of bone phosphate.

ANDERSON COUNTY.

No. 2262—MINERAL WATER: "*From a bored well, eighty feet deep. Sample sent by Henry S. Carl, of Lawrenceburg.*" *Received October 2, 1883.*

A sulphur water. It had made a slight light-grey deposit in the bottles.

COMPOSITION, *in 1000 Parts of the Water.*

Hydrogen sulphide and carbonic acid gases	Not estimated.	
Iron carbonate	0.0046	Held in solution by carbonic acid.
Lime carbonate	.1827	
Magnesia carbonate	.1434	
Lime sulphate	.0700	
Potash sulphate	.0441	
Calcium chloride	.0314	
Magnesium chloride	.1140	
Sodium chloride	4.5000	
Sodium sulphide	.0410	
Silica	.0236	
Lithia, bromine, etc., etc	Not estimated.	
Total saline matters	5.1548 in 1000 parts of the water.	

A good saline sulphur water, very slightly chalybeate, resembling in general properties the celebrated Blue Lick water, but containing somewhat less saline matters than that. The amount of the gases and of the minuter ingredients could only be ascertained by operating on the water fresh at the well and in larger quantities than was furnished for the present analysis.

BELL COUNTY.

No. 2263—"MINERAL WATER: *From Clear Creek Springs, about four miles above Pineville.*" *Collected by Roger C. Ballard, July 11, 1883.*

The water was brought in half-gallon glass preserve bottles, with tight metal covers and rubber collars. It had no perceptible odor when received at the laboratory, although Mr. Ballard states it smells of hydrogen sulphide at the spring. It was almost tasteless and perfectly colorless, with a very slight floculent, brownish deposit in the bottles. "The inhabitants of the region believe they derive benefit from its use as a mineral water.

COMPOSITION, *in 1000 Parts of the Water.*

Carbonate of lime	0.0856	Held in solution by carbonic acid.
Carbonate of magnesia	Trace.	
Sulphate of lime	.0056	
Sulphate of magnesia	.0246	
Chloride of calcium	.0027	
Carbonate of soda	.0316	
Silica	.0076	
Iron oxide, alumina, etc.,	Trace.	
Total saline matters	0.1077	in 1000 parts of the water.

This is nearly a pure water, which could not strictly be classed with mineral waters proper. This, however, does not prevent it from exerting a curative influence in many cases, as it is well known that several so-called mineral waters celebrated because of the cures attributed to their use have been found, by analysis, to be almost pure water. Pure water in proper quantity is a very good depurative agent.

No. 2264—COAL: "*T. G. Killum's, four and a half miles from Pineville and eight and a half miles from Cumberland Gap.*" *Collected by Roger C. Ballard, August 5, 1883.*

A firm, pure-looking coal, containing very little fibrous coal or mineral charcoal. Fracture generally irregular-cuboidal, with glossy, pitch-like surfaces. A few fragments of shaley coal included in the sample, and a little of bright iron pyrites on some of the surfaces. A portion of a pyritous layer was excluded.

No. 2265—COAL: *"At the house of Benj. A. Rice, six miles above Pineville, on Caney Fork of Straight creek. Collected by Roger C. Ballard, July 3, 1883. Bed of coal thirty-six inches thick without any parting."*

A remarkably pure looking coal; pitch black and very glossy on most of its surfaces; very little appearance of mineral charcoal or fibrous coal, and no apparent pyrites; fracture irregular.

No. 2266—COAL: *"Daniel Howard's, on Caney Fork of Straight creek, four miles above Pineville. Bed showing forty-eight inches of coal, including a three-inch parting of cannel coal."*

A pure looking, pitch-black, glossy coal, showing very little fibrous coal and no apparent pyrites.

No. 2267.—COAL: *"Fred. Barner's bank, Yellow creek. Collected by Roger C. Ballard, July 28, 1883. A sample of the coal which would be used in coking on a large scale, throwing out the upper two inches and the seam of iron pyrites."*

(See next following coal.)

A remarkable bright and and pure-looking, soft coal. Fracture irregular and cuboidal; bright, shining on all the surfaces. Hardly any fibrous coal or pyrites. Its fine powder is of a rich, dark chocolate-brown color.

No. 2268.—COAL: *"From same locality and bank as the next preceding sample. An average sample from the entire bed of thirty-four inches. A seam of iron pyrites runs through the bed, twelve inches from the bottom, and another an inch or so from the top; the upper being not so regular as the lower."*

Resembles the next preceding, but is not so bright as that and shows more iron pyrites.

No. 2269—COKE: *"Made by Roger C. Ballard, from the coal of Fred. Barner's bank, Yellow creek, six miles from Pineville, and seven miles from Cumberland Gap, July 29, 1883."*

Quite a hard, spongy coke. Most probably if coked in larger quantities its pores would be smaller.

COMPOSITION OF THESE BELL COUNTY COALS AND COKE.

(*Air-dried.*)

	No. 2264	No. 2265	No. 2266	No. 2267	No. 2268	No. 2269
Specific gravity	1.344	1.241	1.254	1.270	1.281	*a* 1.871
Hygroscopic moisture	1.00	1.00	1.10	.86	.86	.06
Volatile combustible matters	32.70	37.46	36.44	36.04	35.60	.60
Coke	66.80	61.54	62.46	63.10	63.54	99.34
Total	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	33.70	38.46	37.54	36.90	36.46	.66
Fixed carbon in the coke	52.80	60.48	59.66	59.20	57.88	93.34
Ash	13.50	1.06	2.80	3.90	5.66	6.00
Total	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Light Spongy.	Spongy.	Spongy.	Light Spongy.	Light Spongy.	Spongy.
Color of the ash	Lt. ch'te-grey.	Salmon-colored.	Lt. ch'te-grey.	Br. lilac-grey.	Br. lilac-grey.	Dk. pur.-brown.
Percentage of sulphur	2.115	.593	.613	2.082	2.455	1.335

a The specific gravity was taken with the coarsely-powdered coke.

With the exception of No. 2264 these coals are remarkably rich and pure, containing much less than the average proportions of ash and sulphur. The coke, No. 2269, prepared from coal No. 2267, contains but little more than one half of the sulphur which was originally in the coal from which it was made, and, except in its sulphur, compares very favorably with the celebrated Connellsville coke of Pennsylvania, which is so extensively used all over the continent that 8,000 coke ovens, of a daily capacity of 15,000 tons of coke, are in constant operation.*

The COMPOSITION OF CONNELLSVILLE COKE, made by Frick & Co., and analyzed by McCreath, at the Chemical Laboratory of Geological Survey of Pennsylvania, is as follows:

Water (at 225° F.), hygroscopic moisture	.030
Volatile matters	.460
Fixed carbon	89.576
Sulphur	.821
Ash	9.113
Total	100.000

*Scientific American, November 18, 1882, p. 328, from which the above analysis is copied. See Pike county for analysis of the Connellsville coking coal.

The Bell county coke contains nearly 4 per cent. more carbon, and more than 3 per cent. less ash than the Connellsville, and only has about half of 1 per cent. more sulphur than that.

BOYLE COUNTY.

Mineral Waters.

No. 2269—CHALYBEATE MINERAL WATER: "*From four miles, E. of N. of Danville, in a deep gorge on Harrod's Run, or Mock's branch, about 300 yards from where it enters Dix river. The cliffs of limestone are about 300 feet high, and the spring runs out about twenty feet above their base from a horizontal crevice in the rock. Clear as crystal when it first issues and colorless, but becomes red and turbid after a few hours. Water sent by Mr. Edward H. Fox, of Danville. Received September 17, 1881.*"

No. 2270—CHALYBEATE MINERAL WATER: "*From a well eight feet deep, at the Camp Ground near Danville Junction. Sent by E. D. Fox, September 29, 1883.*"

No. 2271—OLD CHALYBEATE SPRING WATER: "*From Alum Springs, on the Knoxville branch of the L. & N. R. R., and half a mile from Danville Junction, on the C. S. R. R. Water sent by Joseph Maxwell.*"

No. 2272—CHALYBEATE WATER: "*From so-called Phosphorus Spring. From same locality as next preceding.*"

COMPOSITION OF THESE CHALYBEATE MINERAL WATERS.

In 1000 Parts of the Water.

	No. 2269	No. 2270	No. 2271	No. 2272
Carbonic acid gas, not estimated	....	....	....	....
Held in solution by carbonic acid: Carbonate of iron	0.0298	....	0.1862	0.1654
Carbonate of manganese	....	....	trace.	trace.
Carbonate of lime	.2257	....	.0199	.0307
Carbonate of magnesia	.0102	....	.0093.	.0133
Sulphate of iron (Fe SO4)	....	.1977	....	....
Sulphate of potash	.0067	.0235	.0140	.0140
Sulphate of lime	.0313	.2917	....	....
Sulphate of soda	.0275	.1521	....	....
Sulphate of magnesia	....	.2250	....	....
Magnesium chloride	.0068	....	....	....
Sodium chloride	....	....	.0042	.0078
Free sulphuric acid	....	.0082	....	....
Silica	.0071	.0384	.0012	.0033
Undetermined and loss	....	.0874	....	....
Total saline matters in 1000 parts of the water	0.3451	1.0240	0.2348	0.2345

The waters numbered 2269, 2271, and 2272 are good chalybeate waters, containing their iron in the form of ferrous carbonate, which is held in solution by carbonic acid, but which on standing exposed to the air separates as ferric hydrate in a reddish sediment. The water No. 2270 contains its iron in larger proportion, in the form of ferrous sulphate—copperas—and hence should be used with greater caution and only under the advice of a physician. This precaution is yet more necessary in regard to the water next to be described.

No. 2273—ALUM WATER: "*Dipped from a small basin, about fifty yards from the Chalybeate well, No. 2270. Sent by Edward H. Fox, September 29, 1881.*"

COMPOSITION, *in 1000 Parts of the Water.*

Sulphate of iron (ferrous sulphate)	2.6761
Sulphate of alumina	5.8477
Sulphate of lime	.4994
Sulphate of magnesia	.1850
Sulphuric acid	.2871
Alkaline salts, silica, etc. (undetermined)	1.5397
Total saline matters, etc.	10.4850

No. 2274—SULPHUR WATER: "*Pumped from a bored well, forty feet deep, about 150 yards from the chalybeate well, No. 2270. Sent by E. H. Fox, September 29, 1881.*"

COMPOSITION, *in 1000 Parts of the Water.*

Hydrogen sulphide and carbonic acid gases	Not estimated.	
Carbonate of iron	0.0097	Held in solution by carbonic acid.
Carbonates of lime and magnesia	.0314	
Sulphate of potash	.0164	
Sulphate of soda	.1841	
Chloride of sodium	.1204	
Carbonate of soda	.5089	
Silica	.0191	
Total saline matters	0.8900	in 1000 parts of the water.

This is a mild, saline, alkaline sulphur water, slightly chalybeate. On exposure to the air, the iron combines with the sulphur and forms the black sediment.

No. 2275—BLACK SULPHUR WATER: "*From Alum Springs, a spring on the Knoxville branch of the L. & N. R. R., half a*

ac

mile from the Danville Junction on the C. S. R. R. Sample sent by Joseph Maxwell."

COMPOSITION, *in 1000 Parts of the Water.*

Hydrogen sulphide and carbonic acid gases	Not estimated.	
Carbonate of iron	0.0342	Held in solution by carbonic acid.
Carbonate of lime	.0396	
Carbonate of magnesia	.0216	
Sulphate of potash	.0066	
Sulphate of soda	.0080	
Chloride of sodium	.0040	
Carbonate of soda	.0870	
Silica	Not estimated.	
Total saline matters	0.2010 in 1000 parts of the water.	

This water resembles the next preceding, but is more strongly chalybeate and much less saline and alkaline than that.

No. 2276—BLACK SULPHUR WATER: "*From a spring called Linney's Well, at Linnietta Springs, formerly Central Kentucky Camp Grounds. Sent by J. S. Linney, Danville, Ky.*"

COMPOSITION, *in 1000 Parts of the Water.*

Hydrogen sulphide and carbonic acid gases	Not estimated.	
Carbonate of iron	0.010	Held in solution by carbonic acid.
Carbonate of lime	1.490	
Carbonate of magnesia	.023	
Sulphate of lime	.267	
Sulphate of magnesia	.160	
Sulphate of potash	.192	
Chloride of sodium	.247	
Chloride of potassium	.006	
Carbonate of soda	.288	
Lithia and bromine	Traces.	
Silica	Not estimated.	
Total saline matters	2.683 in 1000 parts of the water.	

Also a mild, alkaline, chalybeate sulphur water, containing more of the aperient salts than any of the other sulphur waters described above.

No. 2277—WATER: "*From a well eight feet deep, called Petroleum Spring, at Alum Springs. Locality given above. Sent by Joseph Maxwell.*"

No. 2278—EPSOM MINERAL WATER: "*From so-called Fale's Spring at Linnietta Springs. Sent by J. S. Linney, September, 1883.*"

No. 2279—MINERAL WATER: "*Same locality; from so-called Knott's Spring. Sent by J. S. Linney, September, 1883.*"

No. 2280—MINERAL WATER: "*Same locality; from so-called Peter's Spring. Sent by J. S. Linney, of Danville. Received September 13, 1883.*"

COMPOSITION OF THESE BOYLE COUNTY MINERAL WATERS.

In 1000 Parts of the Water. (Carbonic acid not estimated.)

	No. 2277	No. 2278	No. 2279	No. 2280
Held in solution by carbonic acid. Carbonate of iron	a trace	0.102	0.015	0.010
Carbonate of lime	0.0151	.198	.150	1.490
Carbonate of magnesia	.0278	.006	.017	.028
Sulphate of magnesia	trace	3.124	.930	.160
Sulphate of lime	.0408	1.766	.601	.267
Sulphate of potash	.0024	.249	.050	.192
Sulphate of soda	.0016	.152	1.624	. . . .
Chloride of calcium	.0086	. . . .	. . . .	. . . .
Chloride of potassium	. . . .	. . . .	. . . .	.006
Chloride of sodium	trace	n. e.	. . . .	.247
Carbonate of Soda	. . . .	.078	. . . .	.288
Lithia, (chloride or sulphate)	. . .	traces	*.031	†traces
Silica	.0058	n. e.	n. e.	n. e.
Total saline matters in 1000 parts of the water	0.1021	5.675	3.418	2.683

* Lithium chloride. † Bromine, a trace.

Of these waters No. 2277 is nearly pure water, being only slightly calcareous and chalybeate. It may be used for all domestic purposes although a little "hard." No. 2278 is a moderately strong Epsom water and is also slightly chalybeate. No. 2279 contains more sulphate of soda than of Epsom salt as compared with No. 2278, and might also, like that, prove aperient and alterative. No. 2280, containing less sulphate of magnesia than these, has more common salt (chloride of sodium) and sulphate of potash, and is slightly alkaline from the presence of more carbonate of soda. No doubt it would prove diuretic, alterative, and slightly ant-acid.

No. 2280 (A)—"*Water from a salt well forty feet deep, four and a half inches in diameter, about three or four hundred yards from the yards of the Junction City depot, Danville, and about forty yards from the sulphur well, No. 2274. Owned by J. S. Linney. Sample sent by Edward H. Fox, October, 1881.*"

The water had deposited a slight whitish sediment. It had no sensible odor, but a salty taste, and was neutral with litmus paper.

COMPOSITION, *in 1000 Parts of the Water.*

Carbonate of lime	1.454	Held in solution by carbonic acid.
Carbonate of magnesia	1.367	
Sulphate of lime	.139	
Sulphate of potash	.145	
Chloride of sodium	13.878	
Silica, traces of strontia and lithia n. e., and loss	2.217	
Total saline matters	19.200	in 1000 parts of the water.

A weak salt water; too weak to be profitably used for the production of common salt.

No. 2280 (B)—MINERAL WATER: "*From a well ten feet deep, at Linnietta Springs, called by Mr. Linney, 'Procter's Well.'*"

COMPOSITION, *in 1000 Parts of the Water.*

Carbonic acid gas	Not estimated.	
Carbonate of iron	0.035	Held in solution by carbonic acid.
Carbonate of lime	.118	
Carbonate of magnesia	.014	
Sulphate of lime	.240	
Sulphate of magnesia	.128	
Sulphate of potash	.022	
Sulphate of soda	.112	
Chloride of sodium	.007	
Silica	.010	
Lithia, etc., traces	Not estimated.	
Total saline matters	0.686	in 1000 parts of the water.

This is nearly pure water, very slightly chalybeate, which would be wholesome as ordinary drink.

No. 2281—COPROLITES: "*From the base of the Waverly formation, Boyle county. Collected by William M. Linney. Received October 17, 1882.*

Shapes generally oblong, spheroidal or ovoid, somewhat flattened. Exterior of a dull brownish-grey color; interior darker and irregularly cellular. Some of them contained fragments of fossil bones.

On examination they were found to contain bituminous matter, ferrous carbonate, and a considerable proportion of phos-

phates, which in one analysis gave 29.10 per cent. of phosphoric acid (P_2O_5).

Another specimen, of a dark olive-grey color, sent by Mr. Linney at the same time, found at the base of the Waverly, proved to be semi-crystalline barium sulphate.

BREATHITT COUNTY.

No. 2282—COAL: "*From Haddock's Mines, thirty inches of cannel coal, with ten inches of other coal above, separated by one and a half inch parting. Sample collected by C. G. Blakely. Brought August 30, 1881.*"

A pure-looking, firm, tough cannel coal. Fracture satiny in some of the laminæ. Some little pyrites observable, but no fibrous coal.

Two other analyses of this celebrated cannel coal have been made by the present writer; one published in Vol. I, Old Series of Reports of the Geological Survey of Kentucky, page 354, No. 160; the other in Vol. IV., N. S. of same Reports, page 39, No. 1705. These analyses are copied here for comparison.

COMPOSITION OF HADDOCK'S CANNEL COAL.

(*Air-dried.*)

	No. 2282.	No. 160.	No. 1705.
Specific gravity	1.212	1.211	1.287
Hygroscopic moisture	1.60	1.10	1.30
Volatile combustible matters	46.60	48.90	47.00
Coke	51.80	50.00	51.70
Total	100.00	100.00	100.00
Total volatile matters	48.20	50.00	48.30
Fixed carbon in the coke	46.80	47.00	44.40
Ash	5.00	3.00	7.30
Total	100.00	100.00	100.00
Character of the coke	Dense Spongy.	....	Dense.
Color of the ash	Lt. bro'h grey.	Buff colored.	Brown'h grey.
Percentage of sulphur	0.824	0.241	1.574

These three several analyses, made in the years 1855, 1876, and 1881, severally, show that the bed has measurably preserved uniformity of composition during the twenty-eight years of working. It is true that sample No. 1705 shows a higher specific gravity and more ash and sulphur than the other two samples; but it was stated at the time that this was a somewhat weathered specimen, soiled somewhat with earthy and ferruginous matters and showing more than the usual quantity of iron sulphide.

CARTER COUNTY.

No. 2283—COAL, NO. 7 OR COALTON COAL: "*Sample from the fifty-eight-inch bed, in about equal quantities from upper, middle, and lower layers, by Mr. Robert Ellwood, who brought the sample to the laboratory, November 18, 1881, from the Straight Creek Coal Company's mine, near Mt. Savage Furnace, by direction of H. W. Bates, Esq.*"

Bright, pure-looking coal, with very little fibrous coal or pyrites, except a few minute scales of bright iron bi-sulphide on one fragment. The sample was pounded up and thoroughly mixed for analysis.

No. 2284—COAL: "*Herron's cannel coal, on Little Sinking creek, near Aden Station; geological position No. 2. Bed twenty-six inches thick. Collected by A. R. Crandall, December 21, 1881.*"

A very tough, dull-black, cannel coal, showing no fibrous coal between its adherent laminæ. On some surfaces are impressions of minute leaves of ferns; a little pyrites on some portions; fracture, on some of the thick layers, broad conchoidal.

No. 2285—CANNEL COAL: "*Sent by J. M. Bent, Aden Station; owned by Mitchell & Bent, Mt. Sterling. Bed thirty inches thick.*"

An exceedingly tough cannel coal, dull black, showing no fibrous coal and very little pyrites; not readily cleaving into laminæ. Resembles the next preceding.

No. 2286—CANNEL COAL OR BITUMINOUS SHALE: "*From same locality as the next preceding; owned by same persons. Bed thirty inches thick; fifty feet below the next preceding.*

Dull-black or dark slate-colored; cleaving into thin, hard, laminæ, with no fibrous coal and very little appearance of pyrites; some ferruginous incrustations on the exposed surfaces.

No. 2287—CANNEL COAL: "*From Little Sandy. Bed twenty-three inches thick. Owned by Mr. Parsons. Sample from the top and bottom layers, sixteen feet from the outcrop. Sent by J. M. Bent, Mt. Sterling, May 11, 1882.*"

A very tough, pure-looking cannel coal; a portion breaks with some difficulty into irregular laminæ, with some reed-leaf-like impressions in the mineral charcoal between, with very little appearance of pyrites. Another portion is quite compact and homogenous, with flat semi-conchoidal fracture, showing no mineral charcoal or pyrites. Exterior surfaces with ferruginous incrustation.

For comparison with these Carter county cannel coals, the following described sample was sent by Mr. J. M. Bent at the same time for analysis. The result is given in the following table:

No. 2288—CANNEL COAL: "*From West Virginia, at Cannelton. Sample sent by Mr. J. M. Bent. Thickness of the bed, from fifteen to thirty-six inches. Owned by the Cannelton Coal Company. This coal is sold for making gas, in combination with eighty per cent. of common gas coal, in New York and Boston.*"

A very firm, pure-looking cannel coal, glossy black on some surfaces, not readily breaking into layers; fracture broad, irregular, conchoidal. Some little bright pyrites in some parts, but no apparent fibrous coal.

By reference to the table of compositions, it will be seen that the Carter county cannel coals Nos. 2284, 2285, and 2287 exceed this in their proportion of volatile combustible matter, while Table II., at the end of this Chemical Report, shows many cannel coals of Kentucky which are superior in many respects to this for gas-making and other purposes.

COMPOSITION OF THESE CARTER COUNTY AND WEST VIRGINIA COALS, ETC. (*Air-dried*).

	No. 2283	No. 2284	No. 2285	No. 2286	No. 2287	No. 2288
Specific gravity	1.299	1.291	1.203	1.634	1.233	1.185
Hygroscopic moisture	6.30	2.80	1.46	2.04	1.46	0.60
Volatile combustible matters . .	35.54	51.20	54.74	25.86	54.04	42.50
Coke	58.16	46.00	43.80	72.10	44.50	56.90
Total	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	41.84	54.00	56.20	27.90	55.50	43.10
Fixed carbon in the coke . . .	54.82	35.30	33.80	32.10	34.76	49.50
Ash	3.34	10.70	10.00	40.00	9.74	7.40
Total	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Pulverulent.	Dense friable.	Pulverulent.	Dense friable.	Dense.
Color of the ash	Lt. ch'te-grey.	Grey-buff.	Lt. buff-grey.	Lt. buff-grey.	Lilac-grey.	Grey.
Percentage of sulphur . . .	0.881	0.758	1.274	0.781	2.164	1.162

Clays from Carter County.

No. 2288—CLAY: "*From the land of Mr. J. M. Bent. (Is it a fire-clay?)*"

A nearly white clay, slightly tinted with greyish, with some irregular ferruginous mottling and infiltrations in the cracks, and minute scales of mica; quite plastic; burns of a very light flesh color, fuses into a light-grey slag before the blow-pipe. It is, therefore, not a fire-clay, but would make good and handsome terra-cotta objects. If purified from the small amount of oxide of iron it contains it would burn white.

No. 2289—FERRUGINOUS MARLY CLAY: "*From Limestone Mining Company, Limestone Station, Carter county. Sample sent by John R. Procter. Received August 23, 1883.*"

In lumps, easily broken, of a chocolate-brown color, containing small rounded grains of hyaline quartz, and small pebbles, more or less rounded, of various quartzose minerals. By washing, about one-fourth its weight of small rounded quartzose pebbles and fine sand was separated. The residue is a tough,

plastic clay, of a light chocolate color, fusing before the blow-pipe into a dark-colored, nearly black slag.

COMPOSITION, *dried at 230°–240° F.* (*Exclusive of the pebbles and sand.*)

Silica	62.680
Alumina	14.808
Iron peroxide	6.160
Lime carbonate	8.280
Magnesia carbonate	1.650
Phosphoric acid (P2 O5)	.217
Potash	3.108
Soda	.149
Water and loss	2.958
	100.00

This clay might be of some service as a marl on poor sandy soil, provided the cost of transportation does not preclude its use. The washed clay, or even the unwashed, might be employed in the manufacture of common pottery of various kinds.

No. 2290—LIMESTONE: "*Just above the Limestone iron ore and under the plastic clay. Willard, Carter county. Collected by A. R. Crandall. Received July 9, 1883.*

A compact limestone of a cream color, or very light buff, nearly white. Hardness=3.5. Fracture flat conchoidal. Does not adhere to the tongue.

COMPOSITION (*Air-dried*).

Lime carbonate,	96.380	= 53.973 per cent. of lime.
Magnesia carbonate,	1.135	
Alumina and iron oxide,	.980	
Phosphoric acid (P2 O5)	a trace.	
Manganese brown oxide,	.480	= 0.958 manganese carbonate.
Silica and silicates,	.380	
Moisture and loss,	.645	
Total,	100.000	

A very pure limestone, which would yield a pure, white lime, or, if slabs of sufficient size homogeneous in texture could be obtained, might answer for lithographic purposes.

ELLIOTT COUNTY.

No. 2291—CANNEL COAL: "*From head of Buck Fork of Middle Fork of Little Sandy river. Sample from a three and half feet bed (weathered). In the branch. Collected by A. R. Crandall.*

Evidently a much weathered sample, with earthy and ferruginous incrustations, which increase the proportion of the ash. Fracture generally dull, with small specks of mica in some parts. Some laminæ more dense and pure, with imperfect satiny luster on the cross fracture. No pyrites or fibrous coal apparent.

COMPOSITION (*Air-dried*). *Specific gravity 1.388.*

Hygroscopic moisture, ...	2.10	Total volatile matters, . . .	43.44
Volatile combustible matters, . .	41.34		
Dense coke, ...	56.56	Carbon in the coke, ...	85.96
		Light lilac-grey ash, ...	20.60
Totals, ...	100.00	. . . . .	100.00
Percentage of suphur, ...	1.150		

No doubt the proportion of ash would be found much less in the unweathered coal deeper in the bed.

FAYETTE COUNTY.

No. 2292—PHOSPHATIC LIMESTONE: "*From the northern extension, opened July, 1880, of the same quarry, on the Newtown Turnpike, about three miles north of the city limits of Lexington, from which the other samples came, described in Vols. IV. and V., N. S., under the head of Fayette county. Collected by Robert Peter.* (*Lower silurian formation.*)"

Sample from the lower part of the quarry bed, of a dark, dull, bluish-grey color, showing only a few glimmering specks. Adheres to the tongue when dry. Under the lens many minute irregular granules, apparently of organic origin, are visible, with minute fragments of shells or crusts and some very small specks of pyrites.

By titration with uranic acetate this gave 11.34 per cent. of phosphoric acid (P_2O_5).

Six other samples, from the same locality, some bluish-grey and others weathered to a brownish color, gave of *earthy phosphates* an average of about twenty-seven per cent.

Three other samples from the same quarry, collected later from the quarried rock on the turnpike, having the same general appearance, and showing the minute dark-colored granules and the small fragments of shells described above, gave on an-

alysis by the molybdic-acid process, severally 5.692, 6.010 and 13.048, an average 8.25 per cent. of phosphoric acid (P_2O_5).

No. 2293—PHOSPHATIC LIMESTONE: "*From another quarry on the Newtown Turnpike, about half a mile beyond the first toll-gate beyond Lexington, on the farm of Randall Haley. Samples collected by Robert Peter from the rock used for mending the road.*"

This resembles the samples from the other quarry in general appearance, as well as in the fact that it is found in irregular layers between harder and more crystalline, less phosphatic, rock.

On analysis by the molybdic process this yielded 17.651 per cent. of phosphoric acid (P_2O_5).

Subsequently, on a visit to the Haley quarry, four other samples were collected, which on careful analysis yielded severally 16.745, 12.268, 14.315, and 5.597, giving an average of 12.231 per cent. of phosphoric acid (P_2O_5).

There is good reason to suppose that these thin layers of rich phosphatic rock are generally to be found in the so-called blue limestone, which underlies the rich territory of the "Blue-grass" region, and help to give to the soil its great and durable fertility.

No. 2294—WATER: "*From a well bored 120 feet deep, in the southern suburbs of Lexington, in high ground, beyond the State A. and M. College, on Tate's-creek road. Collected by the Rev. John L. Smith.*"

The water had a slight odor and taste of petroleum, and was said to have a slight sulphurous odor when fresh at the well, but when brought to the laboratory had no other gas but a small quantity of carbonic acid.

It gave, on evaporation to dryness, only 0.335 of a part of saline matters to 1000 parts of the water. These consisted of carbonates of lime, magnesia and soda, and a small proportion of sulphate of potash, and some chlorides of sodium and lithium, the water being very slightly alkaline.

It is quite a pure water, suitable for most uses. Taking into-

consideration the depth of the well in the rock, the very small proportion of saline matter contained in the water is quite remarkable.

No. 2295—WATER: "*From a well bored sixty-four feet deep, in the highest ground opposite Ashland (former residence of Henry Clay, deceased), in the suburbs of Lexington, on the old Mentelle Place. Sample brought by Mr. B. Treacy.*"

This water, having no peculiar taste or odor, resembles the next preceding, in being slightly alkaline from the presence of a small proportion of alkaline carbonate. Its total *saline matters*, amounting to only 0.51 of a part in a thousand parts of the water, consist mainly of carbonates of lime, magnesia, and soda, with a small proportion of chlorides. Like that, it contains some carbonic acid gas in solution, and is pure enough for all ordinary purposes and quite wholesome.

No. 2296—WATER: "*From the bored well at the Lexington station of the Cincinnati Southern Railroad. Welt 800 feet deep. The water stands in it at thirty feet below the surface of the ground, which is somewhat elevated, and is pumped from a depth of 550 feet. Sample brought to the laboratory by C. M. Johnson, Esq., Mayor of Lexington, March 16, 1883.*

The water is colorless, with a very slight cloudiness, owing perhaps to the new pump. It has a very slight bituminous odor and a very slight ferruginous taste.

COMPOSITION, *in 1000 Parts of the Water.*

Carbonic acid gas	Not estimated.	
Lime carbonate	0.0998	Held in solution by carbonic acid.
Magnesia carbonate	.0074	
Iron carbonate	.0032	
Silica	.0018	
Lime sulphate	.0243	
Potash sulphate	.0418	
Soda sulphate	.0085	
Magnesium chloride	,1184	
Sodium chloride	.0049	
Soda carbonate	.1368	
Silica	.0022	
Traces of nitrates, etc., and loss	.0024	
Total saline matters	0.4510 in 1000 parts of the water.	

Equal to 8.288 grains in the wine pint of 7,290 grains.

This water is also remarkably pure in relation to the considerable depth in the limestone rock strata from which it is obtained. The small amount of saline matters it contains would generally be considered conducive to health when it is used for drink; and although slightly hard, it is probable that the presence in it of carbonate of soda would measurably prevent the formation of a *hard crust* in the steam boiler in which it may be used.

FLOYD COUNTY.

No. 2297—COAL (No. 3): "*From the mouth of Mud creek. Upper eighteen inches. Collected by A. R. Crandall, November 18, 1881.*"

Generally a firm, pure-looking, pitch black coal. (A piece of what seems to be shale in the sample.) Shows no apparent pyrites and very little fibrous coal.

No. 2298—COAL: "*From the same bed. Lower three feet five inches. Collected by A. R. Crandall, etc., as above.*"

A bright, firm, pure, pitch-black coal, showing very little fibrous coal or pyrites.

No. 2299—COAL: "*Laynesville, Floyd county. Middle of the upper part of the opening, measuring twenty-three inches. Collected by Roger C. Ballard, August 24,* 1882.

A splint coal, breaking into irregular laminæ. No apparent pyrites or fibrous coal.

No. 2300—COAL: "*From the same bed, lower portion, measuring forty-five inches. Collected by Roger C. Ballard, etc.*

A rather brighter coal than the next preceding, which it otherwise resembles.

No. 2301—COAL: "*Mouth of Steele creek, branch of Beaver creek. Collected by A. R. Crandall. Average sample of the upper four feet.*

A pitch-black, pretty pure-looking coal. Some portions laminated and dull.

No. 2302—COAL: "*On Flemming's (or Jack's) creek, left fork of Beaver creek. Sample from a new outcrop of five feet four inches in thickness, without the parting. Some clay unavoidable in the sample. Collected by A. R. Crandall, August 8, 1883.*

A weathered sample of splint coal, with some ferruginous clay incrustations on some pieces. No pyrites apparent.

COMPOSITION OF THESE FLOYD COUNTY COALS.

(*Dried at 212° F.*)

	No. 2297	No. 2298	No. 2299	No. 2300	No. 2301	No. 2302
Specific gravity	1.302	1.281	1.359	1.284	1.328	1.350
Hygroscopic moisture	2.04	2.10	1.80	1.90	2.50	3.80
Volatile combustible matters . .	37.42	37.16	36.70	35.30	32.50	33.80
Coke	60.54	60.74	62.00	62.80	65.00	62.40
Total	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	39.46	39.26	38.00	37.20	35.00	37.60
Fixed carbon in the coke . . .	56.34	57.74	51.70	58.94	56.54	60.60
Ash	4.20	3.00	10.30	3.86	8.46	1.80
Total	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Spongy.	Spongy.	Spongy.	Dense.	Pulvurulent.
Color of the ash	Lilac colored.	Nearly white.	Lt. lilac grey.	Light grey.	Light grey.	Reddish buff.
Percentage of sulphur	1.475	0.596	1.356	0.715	0.651	0.475

These are generally very good coals. Nos. 2299 and 2301 exceed the average proportion of ash somewhat but not excessively, and Nos. 2297 and 2299 show the most sulphur, while the rest of them contain less than the average proportion, and in none of them is this objectionable element excessive.

No. 2303—COKE: "*Made from the Laynesville coal, No. 2299, middle bench, or upper part of the opening. Collected by Roger C. Ballard, August 22, 1882.*"

COMPOSITION (*Air-dried*).

Moisture, driven off at 500° F.	5.00
Fixed carbon	88.50
Reddish-grey ash	6.50
Total	100.00

Its percentage of sulphur is =0.788.

The small proportion of ash in this coke, as compared with the sample analyzed of the coal No. 2299, from which it is said to have been made, seems to show that the sample of coal contained some accidental earthy impurity.

No. 2304—PHOSPHATIC CONCRETIONS: "*Found in tough clay, mouth of Sand branch of Sandy river, five miles above Prestonsburg, Floyd county. Collected by A. R. Crandall, August 20, 1882. 'White, turning to blue.'*"

Small concretions, irregularly spindle-formed, or like two cones joined base to base, sometimes tuberculated and irregularly spiral. Light grey-blue on the exterior surfaces, light grey in the interior, showing some minute spangles of mica.

These singular concretions were found to contain about eight per cent. of phosphoric acid (P_2O_5), and otherwise were mainly composed of silica and sand, alumina and iron oxide—they may possibly be coprolites. The blue color is due to phosphate of iron.

FRANKLIN COUNTY.

No. 2305—PHOSPHATIC LIMESTONE: "*From the Lower Trenton formation, Big Benson creek. Collected by W. M. Linney.*"

A drab-grey rock, mainly made up of small fragments of fossil shells, easily breaking into irregular lamellæ.

COMPOSITION (*Air-dried*).

Lime carbonate	87.760	=49.157 per cent. of lime.
Magnesia carbonate	2.482	
Alumina and iron oxide	3.812	
Phosphoric acid (P_2O_5)	2.968	
Sulphuric acid (SO_3)	n. e.	
Silica and silicates	1.780	
Moisture and loss	1.278	
Total	100.000	

Although this sample does not contain as much phosphoric anhydride as many others from the same geological formation from Fayette county which have been analyzed, it yet shows the general character in this respect of the so-called blue limestone of the lower silurian formation.

No. 2306—WATER: "*From a new reservoir about two miles from Frankfort, situated in a large ravine, across which a dam is built, forming the reservoir, which is said to have an area of an acre and a half, and an average depth of twenty feet. It is supplied by the surface water from the adjoining hills and some two or three low springs.*"

One sample of this water was sent to the laboratory August 12, 1881, by Mr. E. A. Fellmer and Dr. J. Lampton Price, the City Physician; another was sent September 10, 1883, by the City Council.

The first sample had a slight fishy odor, was slightly turbid with a light brownish sediment, and the microscope showed in it the presence of algæ more or less decomposed. The second sample had a more decided disagreeable odor, which resembled that of sewage or of a pig-pen, and on standing a day or two exposed to the air formed a handsome light green scum of living algæ on the surface, while a slight brownish sediment of the dead and decayed organisms had formed at the bottom of the open bottle. The analysis of the first sample gave the following results, viz.:

COMPOSITION, *in 1000 Parts of the Water.*

Total solid matters	0.1000
of which, organic matters	0.0200
and fixed saline matters	.0800
Free ammonia	.0006
Albuminoid ammonia	.00058

The fixed saline matters consisted mainly of carbonates and sulphates of lime and magnesia, with traces of iron and the alkalies. No notable chlorine was found in this first sample, and but a small proportion in the second, which, however, was not quantitatively analyzed. No nitrates or nitrites were detected in the quantity of water examined.

Apart from the living algæ and the organic matters resulting from their decay, which produce the offensive odor, and a little saline matter, this water is nearly as pure as ordinary rain water.

The Rivers Pollution Commission, of Great Britain, obtained the following average results from the examination of seventy-three samples of rain water, all but two of which were collected

at the experimetal farm of Lawes & Gilbert, Rothamsted, England:*

Total dissolved solids, ...	3.950 in 100,000 parts,	. . 0.0395	in the 1000
Organic carbon, ...	.099 in 100,000 parts,	. . .001	in the 1000
Organic nitrogen, ...	.022 albuminoid ammonia,	.0002	in the 1000
Ammonia, ...	.050	.0005	in the 1000
Nitrogen, nitrites and nitrates, .	.007		
Total combined nitrogen, . . .	.071		
Chlorine, ...	.630		

The algæ, which cause surface water to be so offensive, appear only during the warm season, and especially in shallow water freely exposed to the atmosphere. The odor, which is produced by the decay of the minute organism, has been described as a *musty, fishy, cucumber, green-corn, pig-pen, horse-pond, oily* smell. Sometimes, when the water contains sulphates, the odor is more sewage-like because of the presence of hydrogen sulphides.

The practical question not yet fully answered is, whether or not such offensive water is productive of disease. It is highly probable, however, that the statement of the Massachusetts State Board of Health is true in this relation. They say* the evidence tends to show that the plant (the alga) acts mechanically chiefly, perhaps, like unripe fruit, when affecting health at all, in causing diarrhea, *but that the filtered water is harmless.*

No. 2307—SALT WATER: "*From a bored well one hundred and ten feet deep, four and a half inches bore, through solid limestone; the last three feet probably sandstone. Situated four miles east of Frankfort and one mile from the Georgetown Turnpike. Sample sent by A. Stedman, owner of the well, Stedmantown.*"

Much gas escaped at the well at first. The water stands at about twenty-five feet from the top. It has an odor of petroleum, some little of which is found in the well. The *specific gravity* of the water is 1.02.

Evaporated to dryness it left 29.70 parts to the 1000 of the water of brownish *saline matters*, which are mainly sodium chloride (common salt), with carbonate of iron, lime, and mag-

* Quoted from Nichols' *Water Supply*, p. 48. John Wiley & Sons, N. Y., 1888.

nesia, some sulphates and a little of bromides. The proprietor, believing he may "strike oil," or get a salt water strong enough to be profitable, continues to bore by latest account, although the probabilities seem to be adverse.

GRAVES COUNTY.

No. 2308—MARL: "*Sent by Mr. Frank Bray and Judge A. K. Boone, of Mayfield, June 11, 1883. 'Is it a good fertilizer?'*"

An olive-grey marl, partly in soft, friable lumps, containing many fragments of much decomposed shells, with fine-grained hyaline quartz-sand, about 34 per cent., and a small proportion of small, olive-greenish grains of what seems to be glauconite (so-called green sand).

COMPOSITION (*Air-dried*).

Lime carbonate	38.840	=19.514 lime.
Magnesia carbonate	5.077	
Iron carbonate (some iron oxide and alumina not estimated)	11.500	
Phosphoric acid (P_2O_5)	.180	
Potash	1.002	
Soda	.198	
Silica, sand, etc.	39.540	
Moisture and loss	3.663	
Total	100.000	

It might prove useful on sandy or heavy clay soils which are deficient in lime, but would not bear transportation to any distance. If its silica was not mainly in the form of sand it might probably be calcined into a water cement.

GREENUP COUNTY.

Carbonate Iron Ores.

No. 2309—GREY IRON ORE: "*The blue interior portion of the red limestone ore. From near Hunnewell Furnace. Sample sent by H. W. Bates, Vice President of Eastern Railway Company. May 4, 1880.*"

Ore of a brownish-grey color, compact, fine granular. Does not adhere to the tongue. Under the lens appears to be made

up of minute light-brownish grains, with a small portion of whitish cement. Powder drab color.

No. 2310—GREY IRON ORE: "*Found at the Pennsylvania Furnace, lying near the little block ore, between coals Nos. 3 and 4. Sent by H. W. Bates, Esq. Sample from near the outcrop, from a layer eight to fifteen inches thick.*"

An oolitic carbonate, made up of minute brownish spherules, united by a whitish cement. Weathered light-ferruginous on exposed surfaces.

No. 2311—BLACK BAND IRON ORE: "*From the head of Shultz creek. Base of the coal measures. An average sample from sixteen-inch thickness of layer. Collected by A. R. Crandall, July 12, 1882.*"

In irregular laminæ, with some charred vegetable impressions and very thin, irregular laminæ of coal between. Color varying in the laminæ from light to dark grey-brown, and blackish. Adheres to the tongue.

No. 2312—GREY KIDNEY IRON ORE: "*Hibler's Drift, on Shultz creek. Lower limestone ore. Thickness about five inches. Collected by A. R. Crandall, July, 1882. 'Is this the so-called Spiegel ore?'*"

Sample a very hard, irregular kidney, hard enough to strike fire with steel. Mainly light-grey, fine granular; not adhering to the tongue. Portions fine oolitic and brownish.

No. 2313—GREY IRON ORE: "*From Hibler's Drift, lower limestone ore, accompanying the grey kidney ore. Collected by A. R. Crandall, July, 1882.*"

A portion light slate colored, a portion mottled brownish-grey and blackish. Oolitic in parts. Adheres somewhat to the tongue.

No. 2314—BOYCE'S LIMESTONE ORE: "*From north of Dry Fork of Shultz creek. So-called grey limestone ore. Collected by A. R. Crandall, July, 1882. Determine the iron only.*"

Partly brownish limonite, partly compact granular carbonate ore.

COMPOSITION OF THESE GREENUP COUNTY CARBONATE IRON ORES.

	No. 2309 *	No. 2310 †	No. 2311 †	No. 2312 †	No. 2313 †	No. 2314 †
Iron carbonate	81.432	59.418	80.433	65.545	57.043	. . . .
Iron peroxide	. . . .	15.382	.829	. . . .	. . . .	. . . .
Manganese carbonate }	2.758	*a* 1 380	. . . .	*d* 2.096	n. e.	. . . .
Alumina }		4.580	3.172	2.752	2.901	. . . .
Lime carbonate	4.140	2.800	1.790	1.360	1.310	. . . .
Magnesia carbonate	2.187	2.184	5.517	1.816	1.370	. . . .
Phosphoric acid (P2 O5)	.207	.690	.128	.128	.179	1.010
Sulphuric acid (SO3)	.587	*b* .486	n. e.	n. e.	n. e.	. . . .
Silica and silicates	7.670	*c* 12.890	1.220	28.790	27.860	. . . .
Organic matters, moisture and loss	1.019	.248	6.911	3.018	9.337	. . . .
Total	100.000	100.000	100.000	100.000	100.000	100.000
Percentage of iron	39.631	34.780	39.400	30.900	27.540	26.580
Percentage of phosphorous	.095	.285	.056	.056	.078	.441
Percentage of sulphur	.234	.486	n. e.	n. e.	n. e.	. . . .
Percentage of silica	5.820	12.890	1.220	. . . .	. . . .	. . . .

a Brown oxide of manganese. *b* Sulphur. *c* Silica. *d* = 1 p. c. manganese. * Dried at 212°. † Air-dried.

Generally good carbonate ores, requiring roasting before they are smelted. The two latter contain the most iron, and Nos. 2310 and 2314 are the most phosphatic.

No. 2315—GREY IRON ORE: "*A roasted sample of No. 2310. Sent by H. W. Bates, Esq.*

COMPOSITION (*Air-dried*).

Iron peroxide	71.680 =	50.180 iron.
Alumina	5.817	
Lime	2.094	
Magnesia	1.326	
Brown oxide of manganese	1.980 =	1.379 manganese.
Phosphoric acid (P2 O5)	.883 =	.602 phosphorous.
Sulphur	.580	
Silica	16.040	
Hygroscopic moisture	.100	
	100.000	

Limonite Iron Ores from Greenup County.

No. 2316—IRON ORE: "*From Matthews' drift, Shultz creek, Lower limestone ore. Average sample from the eight-inch face, thirty feet in the drift. Collected by A. R. Crandall, July, 1882.*

In irregular laminæ of different tints of lighter and darker grey-brown, some thin lines nearly black. Adheres to the tongue.

No. 2317—GREYCROFT'S BLOCK ORE: "*Head of Shultz creek. Thickness, about eight inches. Collected by A. R. Crandall, July, 1882.*

A limonite ore, containing soft, ochreous ore within hard brown layers.

No. 2318—RED BLOCK ORE: "*Rockhouse branch of Schultz creek. Collected by A. R. Crandall, July, 1882.*"

Resembles the next preceding.

No. 2319—SO-CALLED LIMESTONE KIDNEY ORE: "*Forty feet above the Waverley Ridge, head of Dry Fork of Schultz creek; six inches thick. Collected by A. R. Crandall, July 1882; Resembles the preceding two.*"

No. 2320—SO-CALLED LIMESTONE KIDNEY ORE: "*Rockhouse branch of Schultz creek. Containing less ochreous ore than the preceding, etc. 'Determine the iron.'*"

COMPOSITION OF THESE GREENUP COUNTY LIMONITE IRON ORES.

(*Air-dried.*)

	No. 2316	No. 2317	No. 2318	No. 2319	No. 2320
Iron peroxide	32.260	39.290	51.170	52.500	. . . .
Manganese peroxide	1.642	n. e.	n. e.	n. e.	. . . .
Alumina	2.765	3.960	4.205	4.018	. . . .
Lime carbonate	.490	.320	.160	trace.	. . . .
Magnesia carbonate	1.818	.439	.660	.287	. . . .
Phosphoric acid (P2 O5)	.499	1.010	.945	1.842	. . . .
Sulphuric acid	n. e.	n. e.	n. e.	n. e.	. . . .
Silica and silicates	50.390	46.480	32.080	30.480	. . . .
Water, loss, etc.	10.636	8.501	10.780	10.878	. . .
Total	100.000	100.000	100.000	100.000	. . . .
Percentage of iron	22.750	27.500	35.820	36.750	36.160
Percentage of manganese	1.037	n. e.	n. e.	n. e.	. . . .
Percentage of phosphorous	.217	.689	.412	.804	. . . .
Percentage of sulphur	n. e.	n. e.	n. e.	n. e.	. . . .
Percentage of silica	n. e.	n. e.	n. e.	n. e.	. . . .

These ores, of which the first is rather meager, and the sec-

ond not very much richer in iron, contain generally pretty large proportions of phosphorus.

Pig Irons from Greenup County.

No. 2321—PIG IRON: "*Labeled Strong Grey Pig Iron. Hunnewell Furnace. Made with hot blast at 350° F. Sample sent by H. W. Bates, Esq. December 11, 1880. (Marked Sample No. 1.)*"

A fine-grained, dark-grey iron. Flattened considerably under the hammer. Yielded easily to the file.

No. 2322—PIG IRON: "*Labeled Weak Close Iron, Sample No. 2. Made with hot blast at 500° F. at Hunnewell Furnace. Sent by H. W. Bates, Esq., December 11, 1880.*"

Somewhat lighter grey and a little coarser grained than the preceding. Flattens somewhat under the hammer, but seems to break more readily. Yields easily to the file.

COMPOSITION OF THESE HUNNEWELL FURNACE PIG-IRONS.

	No. 2321	No. 2322
Specific gravity	6.944	6.839
Iron	93.490	92.180
Graphite	3.300	3.000
Combined carbon	.180	.490
Aluminum and manganese	n. e.	n. e.
Silicon	.624	1.760
Slag	2.380	1.780
Phosphorus	.972	.932
Sulphur	.450	.576
Total	101.396	100.718
Total carbon	3.480	3.490

The larger proportions of combined carbon, silicon and sulphur in No. 2322 may possibly account for the difference in the tenacity of the samples.

No. 2323—CINDER, OR FURNACE SLAG: "*Of sample No. 2, Hunnewell Furnace, etc. Sent by H. W. Bates, Esq., etc.*

A homogeneous glass, resembling glassy obsidian, smoky black and only transparent-smoky in very thin splinters. Fuses easily, before the blow-pipe, into a white, blebby glass, in the oxidating flame.

No. 2324—CINDER, OR FURNACE SLAG: "*Of sample No. 2. Same as the preceding, etc. Hot blast 500° F. Weak, close iron made.*"

Generally of a brownish-grey color, full of air-bubbles; only translucent in thin splinters. Fuses easily in the oxidating flame of the blow-pipe into a white, blebby glass.

COMPOSITION OF THESE HUNNEWELL FURNACE SLAGS.

(*Dried at 212° F.*)

	No. 2323	No. 2324
Silica	55.080	55.000
Alumina, iron oxide, etc.	23.980	23.240
Brown oxide of manganese	.580	.680
Lime	19.376	19.152
Magnesia	1.686	1.773
Total	100.702	99.845

These slags are practically similar in composition. According to Mons. P. Hautfeuille, in Wurtz' *Dictionnaire de Chimie, etc.*, a normal iron slag should contain 45 to 60 per cent. of silica, 20 to 35 per cent., of lime, and 12 to 25 per cent of other bases (such as magnesia, oxides of manganese, alumina, etc).

"Alumina makes the *least* fusible silicate and should not exceed 15 per cent.. Magnesia, more fusible, may be 25 per cent. oxide of manganese, is yet more fusible; but if it exceeds 15 per cent., the iron becomes manganiferous." (*Loc. cit.*)

HOPKINS COUNTY.

No. 2325—COKE: "*From the St. Bernard Coal Company mines, Earlington. Sent by John R. Procter, April 4, 1882. Sample in the large bag is made from the washed slack coal. This coke was made at the request of Mr. Procter, the company sending two car-loads to the ovens. Samples carefully taken.*"

No. 2326.—COKE: "*From the same source, made from the unwashed slack coal. A smaller sample.*"

The two samples resemble each other in their external characters, being bright, cellular, and light coke.

COMPOSITION OF THESE TWO HOPKINS COUNTY COKES.
(*Air-dried.*)

	No. 2325	No. 2326
Hygroscopic moisture, etc.—*loss on ignition*	0.86	2.00
Fixed carbon	86.34	77.20
Purplish-grey ash	12.80	20.80
Total	100.00	100.00
Percentage of sulphur	2.233	3.799

It is to be seen that a great improvement in the quality of the coke is made by washing the "slack coal" before coking.

JOHNSON COUNTY.

No. 2327—CANNEL COAL: "*Smith's branch of Paint creek. Average of the cannel coal from the bench opening near the house of Daniel Smith; eighteen inches of cannel overlaid by eighteen inches of common coal; clay and shale below Collected by A. R. Crandall.*"

Coal in thin laminæ, some curved; cross-section generally glossy and pure-looking. Some layers dull. No pyrites or fibrous coal apparent. Seems to be a much-weathered sample.

No. 2328—CANNEL COAL: "*From one mile north of the mouth of Little Paint creek. Upper twenty-two inches of cannel coal. Dr. W. T. Hagar. Collected by A. R. Crandall, August 23, 1882.*"

A dull-black, tough, laminated cannel coal.

No. 2329—CANNEL COAL: "*From same bed as the next preceding, etc. Lower eight inches of cannel coal of Dr. Hagar.*"

Resembles the next preceding. Rather more dull and in thinner laminæ.

COMPOSITION OF THESE JOHNSON COUNTY CANNEL COALS.

(*Air-dried.*)

	No. 2327	No. 2328	No. 2329
Specific gravity	1.279	1.248	1.223
Hygroscopic moisture	3.00	1.80	1.80
Volatile combustible matters	49.80	49.10	49.20
Coke	47.20	49.10	49.00
Total	100.00	100.00	100.00
Total volatile matters	52.80	50.90	51.00
Fixed carbon in the coke	37.94	41.16	44.00
Ash	9.26	7.94	5.00
Total	100.00	100.00	100.00
Character of the coke	Dense.	Dense friable.	Dense friable.
Color of the ash	Lt. grey brown.	Lt. buff grey.	Lt. buff grey.
Percentage of sulphur	2.609	0.816	0.846

Good cannel coals; especially Nos. 2328 and 2329. As frequently noticed before, the specific gravity of the coals increases with the ash proportion.

No. 2330—IRON ORE (CARBONATE): "*Fourteen inches thick, below Wheeler's creek, one and a half miles below Paintsville, Johnson county, below coal No. 1, fifty feet above low water in Big Sandy river. Collected by John R. Procter, August 23, 1882.*

A concretion of small nodules of grey iron carbonate, more or less converted into limonite on the exterior surfaces.

COMPOSITION (*Air-dried*).

Iron carbonate	27.740	Containing 26.04 per cent. of iron.
Iron peroxide	18.159	
Alumina	8.565	
Lime carbonate	1.780	
Magnesia carbonate	1.970	
Phosphoric acid (P_2O_5)	1.205	Containing 0.526 of phophorus.
Silicious residue	35.780	Containing 32.480 of silica.
Moisture, loss, etc.	4.801	
Total	100.000	

Not quite as rich in iron as the average carbonate ores and containing a rather large proportion of phosphorus, it may yet be made available for common iron under favorable conditions.

KENTON COUNTY.

No. 2331—MINERAL WATER: "*From a spring flowing out of the hill through which the tunnel goes, in the "Big Bend" of the Licking river, one hundred and forty rods from the north end of the tunnel, and about the same distance from Grant's Station, ten miles from Covington. Water sent by Mrs. Julia V. McVean, July 24, 1883.*"

COMPOSITION, *in 1000 Parts of the Water.*

Lime carbonate	0.3558	Held in solution by carbonic acid.
Magnesia carbonate	.0082	
Iron carbonate	a trace	
Lime sulphate	1.0039	
Magnesia sulphate	1.3311	
Potash sulphate	.0267	
Soda sulphate	.3944	
Sodium chloride	.1126	
Silica	.0018	
Total saline matters	3.2345	in 1000 parts of the water.

A saline, slightly chalybeate water.

KNOX COUNTY.

No. 2332—COAL: "*From J. N. Wiggins' coal bank, three miles southeast of Barboursville. Collected by R. C. Ballard, May 16, 1883.*

A pure-looking coal, showing very little fibrous coal and no appearance of pyrites.

No. 2333—COAL: "*From head of Dean's branch, near the mouth of Greasy creek. Collected by R. C. Ballard, May 17, 1883.*

A pure-looking coal, showing some little fibrous coal but no apparent pyrites.

No. 2334.—COAL: "*From the same bed as the next preceding; lower portion of the bed, thirty-five inches. Collected by R. C. Ballard, May 17, 1883.*

Like the preceding in general appearance. More firm: seems to be a good so-called "block coal."

No. 2335. COAL: "*From head of Sandy branch, a mile to a mile and a quarter from Flat Lick, on the land of O. P. Ely. Collected by R. C. Ballard, May 29, 1883.*

A pure-looking coal, showing very little fibrous coal and no apparent pyrites.

COMPOSITION OF THESE KNOX COUNTY COALS.

(*Air-dried.*)

	No. 2332	No. 2333	No. 2334	No. 2335
Specific gravity	1.289	1.332	1.261	1.300
Hygroscopic moisture	1.80	1.60	1.66	2.00
Volatile combustible matters	34.00	33.80	36.34	35.00
Coke	64.20	64.60	62.00	63.00
Total	100.00	100.00	100.00	100.00
Total volatile matters	35.80	35.40	38.00	37.00
Fixed carbon in the coke	59.40	57.14	58.04	56.70
Ash	4.80	7.46	3.96	6.30
Total	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Lt. sp'gy	Lt. sp'gy	Lt. sp'gy
Color of the ash	Lt. lilac grey.	Lt. lilac grey.	Nearly white.	Lilac g'y
Percentage of sulphur	0.981	1.110	0.651	1.091

All remarkably good coals, especially Nos. 2332 and 2334.

LAUREL COUNTY.

No. 2336—"*From a bed on Wood's creek, near John Pitman's, on the line of the Knoxville Branch of the L. & N. R. R., in a hill about three hundred and fifty feet high. Bed three feet two inches thick. Three samples, from top, middle, and bottom of the bed. Brought by J. R. Carrigan, of Danville.*

The samples resembled each other greatly, and were all ground together for an average sample.

Coal of a handsome pitch-like, glossy black color, with very little appearance of fibrous coal or pyrites; only a few bright scales on some of the seams. Fracture cuboidal and irregular; some "bird's-eye" structure in some of the pieces; not soiling the hands.

No. 2337—COAL (CANNEL): "*Brought by Captain W. C. Crozier, of Covington, from one and a half miles southwest of London, Laurel county. W. H. Hayden's; bed fifty-three inches thick.*"

No. 2338—COAL: "*From the head of Raccoon creek, one mile from East Bernstadt, Laurel county, three hundred yards from the house of Dr. Ferris. Sample sent by John R. Procter. Received May 30, 1882.*"

A pure-looking, pitch-black, glossy coal, showing very little fibrous coal or granular pyrites. Fracture of some portions conchoidal.

No. 2339—COAL No. 1: "*Pitman Coal Company, Pitman Station. Bed thirty-six inches and a half thick. Fifty yards from the edge of the hill. Sample collected by R. C. Ballard, October 20, 1882.*"

A pure-looking, pitch-black coal. No appearance of pyrites and very little of fibrous coal.

No. 2340—COAL No. 1: "*Laurel Coal Company mine, Pitman Station. A separate piece of two inches of the upper part of the bed, resembling cannel coal in part, not included in the analysis. Collected by R. C. Ballard.*"

Resembles the next preceding.

No. 2341—SLACK: "*Of the Laurel Coal Company coal (coal No. 1). Taken from the dump-pile—(a) the unwashed and (b) the washed sample. Collected by R. C. Ballard, October 23, 1882.*"

COMPOSITION OF THESE LAUREL COUNTY COALS.

(*Air-dried.*)

	No. 2336	No. 2337	No. 2338	No. 2339	No. 2340	No. 2341 (*a.*)	No. 2341 (*b.*)
Specific gravity . . .	1.221	1.496	1.245	1.277	1.267	n. e.	n. e.
Hygroscopic moisture	2.60	1.30	3.30	2.80	2.72	2.60	2.64
Vol. com'ble matters .	35.30	31.00	34.44	35.30	35.32	29.46	34.00
Coke	62.10	67.70	62.26	61.90	61.96	67.96	63.36
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters .	37.90	32.30	37.74	38.10	38.04	32.06	36.64
Fixed carb. in the coke	60.30	43.96	60.96	59.10	58.60	52.54	58.70
Ash	1.80	23.74	1.30	2.80	3.36	15.40	4.66
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Light spongy.	Dense friable.	Light spongy.	Spongy.	Spongy.	Spongy.	Spongy.
Color of the ash . .	Nearly white.	D'k purplish g'y	Brown'h grey.	Lt. lilac grey.	Nearly white.	Brown'h grey.	Lt. lilac grey.
Percentage of sulphur	1.000	4.500	1.055	0.650	0.679	1.241	0.825

With the exception of No. 2337 and 2341 (*a*), which exceed in ash proportion and sulphur, these are all remarkably good pure coals. The so-called cannel coal has so large a proportion of ash material in its composition that it might probably be classed as a rich bituminous shale. While it might be used for ordinary domestic fires its large proportion of sulphur renders it improper for working iron.

No. 2342—COKE OF COAL No. 1: "*Laurel Coal Company, Pitman Station. Sample obtained from the pile, made of coal from all parts of the bed. Collected by R. C. Ballard, October 21, 1882.*"

A moderately fine-grained firm coke.

No. 2343—COKE OF COAL No. 1: "*Laurel Coal Company, Pitman Station. This was made from the slack coal, and is the best I could obtain here. Collected by R. C. Ballard, October 22, 1882.*"

Coke fine-grained and firm; irregularly columnar.

No. 2344—COKE: "*From the Laurel Coal Company's Peacock coal, Pitman Station. Collected by R. C. Ballard, October 22, 1882.*"

A dense, firm, and bright coke.

COMPOSITION OF THESE LAUREL COAL COMPANY'S COKES.

(*Air-dried*).

	No. 2342	No. 2343	No. 2344
Moisture driven off at 480° F.	1.20	0.90	2.40
Fixed carbon in the coke	95.70	92.60	89.20
Ash	3.10	6.50	8.40
Total	100.00	100.00	100.00
Color of the ash	Light bro'nish.	Light bro'nish.	Bro'nish grey.
Percentage of sulphur	0.659	0.739	0.939

Judging from their composition these cokes are both very good, and applicable to all the ordinary uses of coke. Compared with the celebrated Connellsville coke (see Bell county) Nos. 2342 and 2343 contain much less ash and sulphur and a larger percentage of carbon than that. No. 2344 approaches nearer in these respects to the Connellsville coke.

LAWRENCE COUNTY.

No. 2345—COAL: "*Peach Orchard Coal, on Miller's branch of Nat's creek. Entry No. 2. Upper bench of fourteen inches. Collected by A. R. Crandall, June, 1882.*"

A splint coal, splitting into laminæ of variable thickness, with not much fibrous coal between, and very little appearance of granular pyrites. Some of the laminæ are bright and pitch-black, and soften somewhat on being heated; others are more like cannel coal.

No. 2346—COAL: "*From same bed; new entry; middle bench, etc. Collected by A. R. Crandall, June, 1882.*"

Mostly in glossy, pitch-black layers. A pure coal, containing hardly any fibrous coal and no apparent pyrites. Swells up somewhat in the flame of the lamp.

No. 2347—COAL: "*From same bed and entry. Lower bench of twenty-eight inches. New entry No. 2. Collected by A. R. Crandall, June 24, 1882.*"

A firm, pure-looking coal, mostly pitch-black and glossy. Some parts more dull and like cannel coal. Some portions splitting into thin laminæ, with fibrous coal, but no apparent pyrites between; other portions more compact and uniformly pitch-black and glossy on the fractured surfaces. These portions soften and swell considerably in the flame; the others are less changed in form by the heat.

No. 2348—COAL: "*Bone coal of the Peach Orchard coal. Eight inches at the top of the lower bench. Same bed and entry as the preceding. Collected by A. R. Crandall, June, 1882.*"

A dull-black splint coal, breaking with difficulty into irregular laminæ. Mostly cannel-like; softens but little in the flame.

No. 2349—COAL: "*Headley's coal, head of McHenry's branch of Levisa Fork of Big Sandy river. Sample from forty-eight inches in the middle of the bed. Collected by A. R. Crandall, August 1882.*"

A pure, pitch-black, bright coal, with no appearance of fibrous coal, but some bright pyritous scales in portions.

No. 2350—COAL: "*From the Headley coal bed, on the west side of the Levisa Fork of Big Sandy river, five miles above Louisa and two miles and a half from the Chattaroi Railroad. Sample from the face of the central member of the bed, which is four feet eight inches thick. Sent by W. J. Headley. The whole bed is six feet two inches thick, including two slate partings, two and four inches severally.*"

Quite a pure-looking, pitch-black and generally-glossy coal, breaking irregularly, with a tendency to a cuboidal form; very little fibrous coal or granular pyrites apparent, but the sample contained a small portion of a pyritous layer; some ferruginous and earthy incrustations on the exterior surfaces.

COMPOSITION OF THESE LAWRENCE COUNTY COALS.
(*Air-dried*).

	No. 2345	No. 2346	No. 2347	No. 2348	No. 2349	No. 2350
Specific gravity	1.295	1.325	1.287	1.490	1.333	n. e.
Hygroscopic moisture	3.20	3.30	3.90	2.20	4.14	4.50
Volatile combustible matters . .	37.74	22.70	36.80	28.60	33.06	33.70
Coke	59.06	74.00	59.30	69.20	62.80	61.80
Total	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	40.94	26.00	40.70	30.80	37.20	38.20
Fixed carbon in the coke . . .	55.06	64.46	56.30	46.60	54.50	54.38
Ash	4.00	9.54	3.00	22.60	8.30	7.42
Total	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Light spongy.	Dense.	Spongy.	Friable.	Light spongy.	Light spongy.
Color of the ash	Light grey.	Lilac-grey.	Nearly white.	Nearly white.	Purpls'h grey.	Bro'nish grey.
Percentage of sulphur	0.720	1.132	0.756	0.550	1.722	1.703

As may be seen from these analyses, as well as from those published in volume IV., N. S., and by Dr. Owen's analysis, volume I., O. S., the so-called Peach Orchard coal varies somewhat in different localities. It is a "splint" or semi-cannel coal, resembling the "block coal" of Indiana. Its best samples could no doubt be used with advantage in smelting iron ore without previous coking. It is an excellent coal for domestic and many manufacturing purposes, and for the production of steam. The so-called "bone coal," however, contains too much ash to be profitable.

No. 2351—COKE: "*From Peach Orchard coal, Williams' branch, Lawrence county. Collected by R. C. Ballard, Aug. 15, 1882.*"

A bright, firm, dense coke.

COMPOSITION (*Air-dried*).

Moisture, expelled at 220° F.	5.10
Volatile combustible matters, expelled at red heat	.90
Fixed carbon	90.06
Ash (brownish-grey)	3.94
Total	100.00

Its percentage of sulphur is =0.824.

It is purer than the celebrated Connellsville coal, of Pennsylvania, which has 9.113 per cent. of ash. (See Bell county, *anti*).

LETCHER COUNTY.

No. 2352—COAL: "*Holcomb's coal, head of Big Laurel branch, near the head of North Fork of Kentucky river, three miles from Pound Gap. Bed seven feet six inches thick, with an eight-inch parting two feet from the top. Sample from the outcrop, soiled with dirt—hence the ash-finding may be too high. Collected by A. R. Crandall, August 3, 1881.*"

Sample much weathered; weathers in small cuboidal blocks.

No. 2353—COAL: "*Field's coal, on King's creek. Splint and cannel coal, six feet thick. Average sample from a five-feet face. Collected by A. R. Crandall, August, 1881.*"

A mixed sample, partly of bright, pure-looking splint coal, of pitch-black color; partly of tougher, brownish-black, dull, cannel coal, some small ferruginous stains on the exterior surfaces, no appearance of pyrites, and very little of fibrous coal.

No. 2354—COAL: "*J. N. Thompson's coal, on Sandy Lick, a mile and a half from Whitesburg. Sample from the upper layer, twenty to twenty-eight inches thick. A parting of two to sixteen inches separates it from the lower layer, which is thirty to thirty-eight inches thick. Collected by J. Shackelford, August, 1881.*"

(See next number).

A pure-looking, pitch-black splint coal, quite brilliant on the fractured surfaces and on some of the faces of the laminæ. Very little fibrous coal apparent, and no visible pyrites.

No. 2355—COAL: "*Sample from the lower layer of J. N. Thompson's coal, etc.*"

This sample contains some dull layers, with a thin, pyritous laminæ and more fibrous coal than in the preceding sample.

No. 2356—COAL: "*From Mr. Nickel's coal-bank, below Whitesburg, on the Kentucky river. Collected by A. R. Crandall, August 3, 1881.*"

A much-weathered sample of splint coal. Shows some fibrous coal in the form of reed-leaf-like impressions between the irregular laminæ; no pyrites apparent, but a red-ochreous incrustation on some of the exterior surfaces.

No. 2357—COAL: *"J. M. Collins' coal, on Rockhouse creek. Bed three feet eight inches thick. Average sample. Collected by A. R. Crandall, August, 1881."*

A pure-looking splint coal.

No. 2358—COAL: *"From Caudell's bank, a mile and a half below Whitesburg, on the Kentucky river. A sample of the upper layer, twenty-five inches thick, a slate parting below of eight to fourteen inches, including a thin coal. Collected by A. R. Crandall."*

Appears to be a pure sample of splint coal, some fibrous coal between the laminæ, but no apparent pyrites.

No. 2359—COAL: *"From the same bank. A sample of the lower layer, twenty-eight inches thick. Collected by A. R. Crandall.*

A weathered sample; approaches cannel coal in some of the laminæ.

No. 2360—COAL: *"From Laurel branch of Kentucky river. Upper two feet. Sample from the weathered face of the bed. Collected by A. R. Crandall, November 10, 1881."*

Sample much weathered and somewhat friable, the seams covered generally with a greyish incrustation, part of which seems to be clay, which may increase the apparent ash percentage. Some fibrous coal between the laminæ, but no pyrites apparent.

No. 2361—COAL: *"From the same bed as next preceding. Sample from the lower sixty-eight inches. Thickness of the whole bed, eight feet."*

Generally a bright, pitch-black, pure-looking coal, except in the somewhat weathered portions. A little fibrous coal and fine granular pyrites between the laminæ, and a few bright, thin pyritous scales in some of the seams.

No. 2362—COAL: "*From Cowan Ridge, opposite Whitesburg. A splint coal, four hundred and ninety feet above the bed of the river. Bed of coal forty-one inches thick without parting. Entry driven in twenty feet. Collected by A. R. Crandall.*"

Quite a pure-looking, pitch-black coal. Some fibrous coal between the laminæ, but very little granular pyrites. Quite a firm coal.

No. 2363—COAL: "*Camp Branch of Rockhouse creek. Dr. S. H. Breeding's coal. The lower forty-five inches. Collected by A. R. Crandall, July 20, 1883.*"

A pure-looking, pitch-black coal. Fracture irregular and cuboidal, with generally brilliant surfaces. No fibrous coal and very little granular pyrites apparent.

No. 2364—COAL: "*On J. Q. Benthey's farm, Rockhouse creek. Collected by J. A. Shackelford, July 24, 1883.*"

A cannel coal. Sample much soiled with argillaceous material. No apparent pyrites. It seems to be a weathered sample.

No. 2365—COAL: "*On Sam Kiser's place, on Love Branch of Rockhouse creek. Collected by J. A. Shackelford, July 24, 1883.*"

A much weathered sample of what seems to be a splint coal. Much soiled with ferruginous and argillaceous material.

No. 2366—COAL: "*On Sam Kiser's land, Love Branch of Rockhouse creek. From a big slip from an upper bed just below the other Kiser sample. Thickness six feet. Not driven into the hard coal. Collected by J. Shackelford, July 27, 1883.*"

A much weathered sample, much soiled with clay, etc. In small pieces.

No. 2367—COAL: "*From John Amberger's farm, on Wolf-pen creek of Carr's Fork of Kentucky river. Upper thirty-four inches of the cannel coal bed. The remaining thickness of the bed is represented by the next sample.*"

A much weathered sample, in small lumps and powder. Soiled with clay.

No. 2368—COAL: "*Same locality and bed as next preceding. Thickness twenty-six inches. Lower part of the cannel bed. Collected by A. R. Crandall, July 27, 1883.*"

A firm, pure-looking cannel coal.

No. 2369—COAL: "*On Marion Hale's farm, Trace Branch of Rockhouse creek. Upper part of the cannel coal. Thickness thirty-two inches.*"

A very pure-looking, pitch-black coal. Fracture generally irregular, with brilliant surfaces. Small bird's-eye structure in parts. No fibrous coal apparent, and very little of bright pyrites.

COMPOSITION OF THESE LETCHER COUNTY COALS. (AIR-DRIED.)

(I.—The eleven samples collected in 1881).

	No. 2352	No. 2353	No. 2354	No. 2355	No. 2356	No. 2357	No. 2358	No. 2359	No. 2360	No. 2361	No. 2362
Specific gravity	1.291	1.292	1.191	1.279	1.286	1.242	1.277	1.286	1.355	1.319	1.320
Hygroscopic moisture	3.26	1.10	1.10	1.10	1.84	1.46	1.30	1.60	8.00	2.86	1.34
Volatile combustible matters	32.24	34.30	40.90	34.30	33.26	35.84	39.60	36.40	30.06	31.54	34.16
Coke	64.50	64.60	58.00	64.60	64.90	62.70	59.10	62.00	61.94	65.60	64.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	35.50	35.40	42.00	35.40	35.10	37.80	40.90	38.00	38.06	34.40	35.50
Fixed carbon in the coke	61.60	58.10	55.40	57.20	59.70	58.60	55.20	56.60	57.60	62.10	56.70
Ash	2.90	6.50	2.60	7.40	5.20	4.10	3.90	5.40	4.34	3.50	7.80
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Dense.	Spongy.	Spongy.	Spongy.	Dense.	Light Spongy.	Light Spongy.	Light Spongy.	Pulverulent.	Dense.	Spongy.
Color of the ash	Lt. buff.	Lt. buff-grey.	Brow'h-grey.	Lt. grey.	Lt. buff-grey.	Brow'h-grey.	Brownish.	Brow'h-grey.	Lt. buff.	Lt. buff.	Cho'l'te-grey.
Percentage of sulphur	.656	.890	1.453	.889	.678	1.068	2.812	1.060	.494	.535	1.318

These are remarkably good coals, containing less than the average of ash and sulphur, except that No. 2358 shows more than the average of sulphur, and Nos. 2355 and 2362 exceed somewhat the average ash proportion.

COMPOSITION OF THESE LETCHER COUNTY COALS. (AIR-DRIED.)

(II.—The seven samples collected in 1883).

	No. 2363	No. 2364	No. 2365	No. 2366	No. 2367	No. 2368	No. 2369
Specific gravity	1.317	1.305	1.373	1.483	1.385	n. e.	n. e.
Hygroscopic moisture	1.26	1.90	7.70	6.66	5.46	0.26	1.30
Volatile combustible matters	40.30	39.32	35.50	31.00	31.68	47.94	38.10
Coke	58.44	58.78	56.80	62.34	62.86	51.80	60.60
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	41.56	41.22	43.20	37.66	37.14	48.20	39.40
Fixed carbon in the coke	52.70	51.88	51.96	46.94	57.46	44.86	58.40
Ash	5.74	6.90	4.84	15.40	5.40	6.94	2.20
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Dense.	Dense.	Pulver-ulent.	Pulver-ulent.	Pulver-ulent.	Dense.	Light Spongy.
Color of the ash	Gr.-pur-plish.	Purpl'h-grey.	Lt. gryh-brown.	Purpl'h-grey.	Lt. purp-grey.	Buff-grey.	Purpl'h-grey.
Percentage of sulphur	2.752	1.115	.832	.488	.488	.751	.710

These are also good coals, although No. 2363 gives more than the average proportion of sulphur. No. 2369 is remarkably pure, giving only 2.20 per cent. of ash. The apparent ash percentage in Nos. 2365, 2366, and 2367, the weathered samples, from the outcrop of the beds, is probably much greater than would be found in the unaltered coal deeper in the bed; these samples being no doubt much contaminated with earthy matters.

The effects of exposure to the atmospheric agencies—weathering—are shown in these samples by the great increase of hygroscopic moisture, owing to the disintegration of the coal; the diminution of their volatile combustible matters; the decrease of their proportion of sulphur by oxidation and otherwise; the increase of their ashy or earthy constituents, and consequently of their specific gravity. Their coke made from the powdered coal is also pulverulent or non-coherent.

LOGAN COUNTY.

No. 2370—MINERAL WATER: "*From a spring, owned by Abram Sharp, five miles northwest of Lewisburg, on Raw-hide creek; three miles west of O. & W. Railroad. (N. W. part of Logan Co.) The water flows about forty gallons per hour. Sample sent by B. G. Williams, of Lewisburg, July 27, 1883.*"

No. 2371—MINERAL WATER: "*From a spring, owned by C. P. Burgher; called by him 'Fountain of Life;' three miles northwest of Russellville. Sample sent by John W. Caldwell, of Russellville, October 6, 1883.*

COMPOSITION OF THESE MINERAL WATERS.

In 1000 Parts of the Water.

	No. 2370	No. 2371
Iron carbonate	.0561	*.3260†
Lime carbonate	.0504	*.3485
Magnesia carbonate	.0094	*.0101
Lime sulphate	.3134	1.1886
Magnesia sulphate	.0000	.9378
Iron sulphate	.0000	a trace.
Soda sulphate	.1066	.0000
Potash sulphate	.0142	.0000
Magnesium chloride	.0170	.0000
Sodium chloride	.0000	.0900
Lithia	.0000	m'rk'd traces.
Silica	.0100	.0048
Total saline matters, in 1000 parts of the water	.5771	2.9053

*Held in solution by carbonic acid. †Contains manganese.

These two mineral waters have a general similarity of composition; being both saline chalybeate waters. But No. 2371

is much the stronger, especially as a chalybeate. The iron of this water is also accompanied by a small proportion of manganese, and lithia is present in it in notable small proportion.

MAGOFFIN COUNTY.

No. 2372—COAL: "*From Stone's bank, on Oakley creek, half a mile from the mouth. Whole thickness thirty-five inches. Sample from the lower twenty inches. Collected by A. R. Crandall, November, 1881.*"

Quite a firm coal, cleaving with some difficulty into irregular laminæ, with some fibrous coal between, but no apparent pyrites. Generally pitch-black and glossy on the fractured surfaces.

No. 2373—COAL: "*From same bank as next preceding. Sample from the upper fifteen inches. Collected by A. R. Crandall, November, 1881.*"

Apparently a weathered sample. Friable, cleaving in thin laminæ. Of a dark-slate color on the exterior surface (caused by weathering?); black in the interior. No apparent pyrites.

COMPOSITION OF THESE MAGOFFIN COUNTY COALS.
(*Air-Dried.*)

	No. 2372	No. 2373
Specific gravity	1.303	1.482
Hygroscopic moisture	2.16	6.92
Volatile combustible matters	36.98	29.28
Coke	60.86	63.80
Total	100.00	100.00
Total volatile matters	39.14	36.20
Fixed carbon in the coke	53.86	46.80
Ash	7.00	17.00
Total	100.00	100.00
Character of the coke	Light spongy.	Pulverulent.
Color of the ash	Nearly white.	Light grey.
Percentage of sulphur	0.535	0.541

The upper layer seems to have been much "weathered," hence probably its larger proportion of hygroscopic moisture and its smaller proportion of volatile combustible matters. The lower layer gives very good coal, and further in the bed the upper layer may be found to improve in quality.

MARTIN COUNTY.

No. 2374—COAL: "*G. W. Ward's, head of Lick Branch of Cold Water Fork of Rockcastle creek. Sample from the upper two feet, the lower one foot being covered. Collected by A. R. Crandall, June 22, 1882.*"

A pure looking splint coal (block coal), splitting with some difficulty into thin laminæ, with some fibrous coal, but no apparent pyrites between.

No. 2375—COAL: "*From Scaffold Lick Branch of Rockcastle creek. Six feet bed; five and a half feet, exclusive of parting. Collected by A. R. Crandall, June 24, 1882.*"

A firm splint or block coal, with very little fibrous coal and no appearance of pyrites between the irregular laminæ. Some of these, dull black, are of the nature of cannel coal; others are glossy and pitch-black, and soften somewhat in the flame of the lamp.

No. 2376—COAL: "*On Beech Fork of Rockcastle creek. (Coal No. 2.) Bed three feet eight inches thick, with a five-inch parting. Collected by A. R. Crandall.*"

A pure-looking coal; partly pitch-black, with shining fracture; a portion more dull and cannel-coal-like.

No. 2377—COKE: "*Of the next preceding coal, No. 2. Made in an open fire. Collected by A. R. Crandall.*"

COMPOSITION OF THESE MARTIN COUNTY COALS AND COKE.

(*Air-dried*).

	No. 2374	No. 2375	No. 2376	No. 2377
Specific gravity	1.291	1.341	1.342	n. e.
Hygroscopic moisture	2.60	3.54	2.20	0.80
Volatile combustible matters	35.50	31.36	33.10	. . . .
Coke	61.90	65.10	64.70	. . . .
Total	100.00	100.00	100.00	. . . .
Total volatile matters	38.10	34.90	35.30	. . . .
Fixed carbon in the coke	56.86	56.30	55.10	90.20
Ash	5.04	8.80	9.60	9.00
Total	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Dense.	Spongy.	. . . .
Color of the ash	Nearly white.	Lt. lilac grey.	Light grey.	Redish brown.
Percentage of sulphur	0.608	0.565	0.578	0.582

These are good coals, containing less than the average proportion of sulphur; but Nos. 2375 and 2376 contain more than the average ash proportion. It is probable, however, that this will be less in the coal deeper in the bed.

MERCER COUNTY.

No. 2378—LIMESTONE: "*Chazy Limestone* (*Sample No. 1*), *from Kentucky river cliffs. Collected by Wm. M. Linney. Received February 23, 1883.*"

A compact, very fine granular limestone of a warm-grey color. Does not adhere to the tongue. Contains no apparent fossils.

No. 2379—LIMESTONE: "*Chazy Limestone* (*Sample No. 2*), *from Kentucky river cliffs. Collected by W. M. Linney. Received February 23, 1883.*"

A compact limestone of a grey color, irregularly mottled with lighter grey in consequence of the presence of fossil remains. Does not adhere to the tongue.

COMPOSITION OF THESE MERCER COUNTY CHAZY LIMESTONES.
(*Air-dried.*)

	No. 2378	No. 2379
Lime carbonate	62.860	83.040
Magnesia carbonate	30.720	10.550
Alumina in iron oxide with traces of phosphoric acid	1.220	.980
Sllicious residue (insoluble in acids)	5.000	5.560
Moisture, etc.	0.130	2.30
Total	99.930	100.360

No. 2378 contains 35.20 per cent. of lime, and No. 2379 contains 46.50 per cent. They are both magnesian limestones, and would calcine into very good white lime. Possibly No. 2378, which contains the most magnesia, might, if properly calcined, be found to produce a hydraulic cement, but not of so durable character as that prepared from more silicious limestones. No doubt they are both good durable building stones.

MORGAN COUNTY.

No. 2380—CANNEL COAL: "*From Williams' bank, Rush branch of Elk Fork of Licking river. Average sample of the fifty-eight-inch bed. Collected by A. R. Crandall.*"

Quite a tough cannel coal, with imperfect lamination. Fracture dull or brownish-black, with a few minute specks of mica on some of the surfaces. No appearance of pyrites and very little of fibrous coal. Ferruginous stain on the exterior surfaces.

No. 2381—COAL NO. 2: "*Forty-inch cannel coal, opposite the house of Joel Adkins, head of North Fork of Licking river. Sample from the outcrop. The whole thickness is in the bed of the branch. Collected by A. R. Crandall, June, 1881.*"

A tough, dull-black cannel coal; laminated. Some of the thicker and more dense laminæ break with a flat-conchoidal fracture. Not much fibrous coal or granular pyrites apparent but there are some small pyritous lumps in the body of the coal. Some of the laminæ are quite shaley. Ferruginous stains on the exterior surfaces.

No. 2382—COAL No. 2: "*Three feet cannel coal, left branch of Mordecai creek. Average sample from the upper thirty-two inches. Collected by A. R. Crandall, June 13, 1881.*"

Resembles the preceding, but darker colored than that, with less ferruginous incrustation and showing no pyrites.

No. 2383—COAL No. 2: "*Another average sample from the upper thirty inches of the same bed. (One foot uncovered, the lower six inches more slatey.) Brought by A. R. Crandall, April 6, 1882.*"

Resembles the preceding.

No. 2384—COAL: *Prater's cannel coal, on Stone Coal branch of Caney creek, one mile above Walnut Grove. Thickness two feet. Collected by A. R. Crandall, June, 1881.*"

A pure-looking, firm, jet-black coal, showing only a few small scales of pyrites between some of the laminæ. Some ferruginous stain on some of the exposed surfaces.

No. 2385—COAL No. 1: "*On a fork of Smith's creek. Bed thirty inches thick. Average sample of the whole thickness. Collected by A. R. Crandall.*"

Apparently a splint coal, breaking into thin laminæ, with some fibrous coal and granular pyrites between.

COMPOSITION OF THESE MORGAN COUNTY COALS.

(*Air-dried.*)

	No. 2380	No. 2381	No. 2382	No. 2383	No. 2384	No. 2385
Specific gravity	1.382	1.348	1.378	1.303	1.294	1.358
Hygroscopic moisture	1.60	4.26	3.90	2.02	2.20	2.90
Volatile combustible matters	44.00	42.48	39.30	41.98	40.50	39.10
Coke	54.40	53.26	56.80	56.00	57.30	58.00
Total	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	45.60	46.74	43.20	44.00	42.70	42.00
Fixed carbon in the coke	38.86	33.76	38.80	44.06	50.30	51.34
Ash	15.54	19.50	18.00	11.94	7.00	6.66
Total	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Dense.	Pulverulent.	Friable.	Dense.	Dense.	Dense spongy.
Color of the ash	Buff-grey.	Fawn-colored.	Grey-brown.	D'k purplish g'y.	Nearly white.	D'k lilac grey.
Percentage of sulphur	0.961	1.535	1.106	0.810	0.805	4.527

With the exception of Nos. 2384 and 2385, these coals greatly exceed the average ash proportion. Most probably this is partly owing to the fact that the samples in these cases were taken from the weathered outcrop of the bed. No. 2385 contains quite a large proportion of sulphur. Whether the sample was exceptional in this respect, can only be ascertained by the analysis of other samples from the same bed.

Morgan County Soils.

No. 2386—VIRGIN SOIL: "*From woods, with a northern exposure, one hundred and twenty-five feet above Spaw's creek, near Licking river. Timber, oak and maple, undergrowth the same, with dogwood, hickory, etc. Geological position, coal No. 3. Collected by A. R. Crandall, July 19, 1881.*"

Dried soil, of brownish dark-grey color, with small friable clods, containing fragments of sandy and ferruginous shale or concretions, mostly of irregular, flattened forms.

The coarse seive* removed from it 37.73 per cent. of hard sandy, ferruginous, shaley fragments, flattened, and with angles rounded. Its silicious residue all passed through the fine seive,† except a very few small rounded quartzose grains.

No. 2387—SUBSOIL: *Of the next preceding.*

The dried subsoil is mostly in moderately firm sods, generally of a light orange-brown color, light-grey in the course of the vegetable rootlets which penetrated it. Contains some fragments of soft ferruginous and sandy shale or concretions.

The coarse seive removed from it 13.09 per cent. of ochreous concretions or ferruginous shale, containing fine sandy particles, flattened but rounded on all the angles, softer than those of the preceding sample. Its silicious residue all passed through the fine seive except a few small rounded quartz grains.

No. 2388—SOIL: "*From an old field, taken three to six inches from the surface. Bottom land on Spaw's creek, near Licking river. Geological position, coal No. 2. Soil derived from the rocks above. Collected by A. R. Crandall, July 18, 1881.*"

The dried soil is friable, of a brownish-yellowish grey color. Contains but few shaley fragments or concretions.

The coarse seive* removed from it 2.31 per cent. of ferruginous or shaley concretions, etc. The fine seive† separated from its silicious residue 21 per cent. of small rounded white quartz grains.

No. 2389—SUBSOIL: "*Of the next preceding, etc., etc., taken one foot six inches below the surface. Collected by A. R. Crandall.*"

The dried subsoil is mostly in clods, of a lighter and brighter tint than the next preceding. (Light brownish-grey yellow.) Contains but few concretions or shaley fragments.

The silicious residue left on the fine seive 21.80 per cent. of fine rounded white quartz grains. The coarse seive removed from it only 2.11 per cent. of ochreous and ferruginous concretions or fragments.

*The coarse seive has 64 meshes to the square centimeter.
†The fine seive has 1600 meshes to the square centimeter.

No. 2390—OLD-FIELD SOIL: "*From the land of Amos Fugit, two miles above West Liberty, near the Licking river. Geological position, coal No. 3. On the hillside, western exposure, one hundred and fifty feet above the river. The hill is one hundred and fifty feet higher. Collected by A. R. Crandall, July 19, 1880.*"

The dried soil is friable, of a warm brownish-grey color. The coarse seive removed from it 11.85 per cent. of brownish ochreous concretions, etc. The fine seive separated from its silicious residue 12.65 per cent. of fine white sand in rounded grains.

No. 2391—SUBSOIL: *Of the next preceding, etc., etc.*

The dried subsoil is mostly in friable clods of a handsome light brownish-yellow ochre color. This and the three preceding soils contain fine quartz sand. The coarse seive removed from it only 0.51 per cent. of brownish ochreous concretions. The fine seive separated from its silicious residue 13.60 per cent. of fine rounded grains of white quartz sand.

COMPOSITION OF THESE MORGAN COUNTY SOILS.
(*Dried at 212° F.*)

	No. 2386	No. 2387	No. 2388	No. 2389	No. 2390	No. 2391
Organic and volatile matters	6.595	4.240	3.305	2.650	3.415	3.225
Alumina and iron and manganese oxides	8.429	6.577	3.655	4.121	3.505	5.262
Lime carbonate	.325	.120	.335	.245	.170	.120
Magnesia	.718	.699	.412	.232	.261	.299
Phosphoric Acid, (P_2O_5)	.156	.118	.115	.124	.140	.108
Potash, extracted by acids, (K_2O)	.236	.153	.104	.043	.082	.121
Soda, extracted by acids, (Na_2O)	. . . .	.308	.156	.071	. . . .	. . . .
Water, expelled at 380° F.	1.570	.835	.810	.600	.860	.625
Sand and insoluble silicates	82.170	87.570	91.450	91.682	91.485	90.180
Total	100.199	100.620	100.342	99.768	99.918	99.940
Hygrocopic moisture	2.415	1.600	1.150	0.960	0.885	1.115
Potash in the insoluble silicates	2.384	2.757	1.727	1.911	1.410	1.723
Soda in the insoluble silicates	.350	.380	.490	.410	.316	.286
Fine sand in the insoluble silicates	.000	.000	21.000	21.800	12.650	13.600
Rock fragments or concretions	37.730	13.09	2.310	2.110	11.850	0.510
Character of the soil	Virgin soil.	Subsoil.	Old-field soil.	Subsoil.	Old-field soil.	Subsoil.

The virgin soil No. 2386 is of rather more than average fer-

tility, although it is to be discounted by 37.73 per cent. of rock fragments or ferruginous concretions. Most of these, however, may be gradually disintegrated into soil by the process of weathering. The subsoil seems to be less rich in the mineral elements of fertility, as well as in organic matters, than the surface soil. The old-field soils No. 2388, as well as No. 2390, show a diminution of the essential elements as compared with the virgin soils. With the exception of Nos. 2389 and 2390, which are somewhat deficient in immediately available potash, these soils may be considered as of average fertility under favorable conditions, and they all may be made permanently productive by judicious management and the proper use and economy of fertilizers.

MUHLENBERG COUNTY.

No. 2392—COAL: "*From the 'Mud River Mines.' Sample clipped from three large blocks taken from the middle and bottom of the bed. Sent by John R. Procter, June 22, 1882.*"

A pure-looking, pitch-black coal, glossy on most of the fractured surfaces. Very little appearance of fibrous coal. Some little bright scales of pyrites in some of the seams. Large fracture, in cuboidal blocks; smaller fracture irregular, with shining facets. Softens somewhat in the flame, and swells up into a spongy coke.

COMPOSITION (*Air-dried*).

Specific gravity			1.268
Hygroscopic moisture	6.46	Total volatile matters	40.50
Volatile combustible matters	34.04		
Spongy cake	59.50	Fixed carbon in the coke	55.50
		Light lilac-grey ash	4.00
Total	100.00	Total	100.00

Its percentage of sulphur is 0.802.

A very good, pure coal, which seems to possess coking qualities. The large proportion of moisture in this sample is somewhat exceptional, and probably accidental.

NELSON COUNTY.

No. 2393—SANDSTONE (PHOSPHATIC): "*From the black Devonian slate, in the Boston district. Locally ten inches thick. Con-*

tains fish and other organic remains. Collected by W. M. Linney. Received June 29, 1883."

A grey sandstone, mostly made up of hyaline grains of quartz, somewhat rounded, mixed with dark-colored granules and broken organic remains.

On analysis this rock was found to contain 67.04 per cent. of silicious material, with smaller proportions of alumina, oxide of iron, lime, and magnesia, not determined, with which was combined 11.162 per cent. of phosphoric acid (P_2O_5), equivalent to 24.372 per cent. of bone phosphate. It also contained traces of the alkalies, in which was potash equal to 0.019 per cent. of the rock.

No. 2394—LIMESTONE (FERRUGINOUS): "*From near the top of the upper Hudson river beds. Cumberland sandstones and shales. Collected by W. M. Linney, near the farm of S. P. Stiles, four miles north of Bardstown, May 5, 1883.*"

A fine granular rock of a dull-grey color; brownish-yellow on the weathered portions. Not adhering to the tongue.

No. 2395—LIMESTONE (FERRUGINOUS): "*From near S. P. Stiles'. Cumberland sandstones and shales. Upper part of upper Hudson river beds. Collected May 5, 1883, by W. M. Linney.*"

A fine granular rock of a brownish-yellow ochre color. Not adhering to the tongue.

COMPOSITION OF THESE NELSON COUNTY FERRUGINOUS LIMESTONES.
(*Air-dried.*)

	No. 2394	No. 2395
Lime carbonate	81.580	61.240
Magnesia carbonate	1.501	8.915
Alumina and iron oxide	2.978	4.317
Phosphoric acid (P_2O_5)	1.202	.563
Potash	.428	.443
Soda	.248	.254
Silicious residue	11.120	22.520
Moisture and loss	.948	1.748
Total	100.000	100.000
Percentage of lime	45.685	34.294

Judging by the composition of sample No. 2395, it is probable that by skillful management in calcination it might furnish hydraulic cement. No. 2394, containing less silicious matter, might be made available in all the ordinary uses of lime for building purposes; and both, if to be obtained in proper shape, would make good building stones. They would yield fertile soil by the slow process of weathering.

No. 2396—SOIL: "*From the farm of S. P. Stiles, four miles north of Bardstown. Derived from the Cumberland shales. Geological position, upper part of the upper Hudson river beds. Collected by W. M. Linney, May 5, 1883. Said to be quite poor, soft, light soil. Has been cultivated for a long time, perhaps forty years. Does not wash badly.*"

Soil of a light brownish-buff color. Clods friable. All passed through the coarse seive, which has 64 meshes to the square centimeter, except a small quantity of ferruginous concretions—shot iron ore. Its silicious residue, from digestion in acids, all passed through the fine seive with 1600 meshes to the centimeter square, except two or three small quartzose particles.

COMPOSITION. (*Dried at 212° F.*)

Organic and volatile matters	3.020	
Alumina and oxides of iron and manganese	9.772	
Lime carbonate	.145	
Magnesia	.305	
Phosphoric acid (P_2O_5)	.173	
Potash, extracted by acids (K_2O)	.438	
Soda, extracted by acids (Na_2O)	..	
Water expelled at 340° F.	.612	
Sand and soluble silicates	84.820	containing 1.200 p. c. potash. and .646 p. c. soda.
Total	99.285	

Hygroscopic moisture=2.350 per cent.

No reason appears, except perhaps its small proportion of organic matters—*humus*—why this soil might not yet be reasonably productive under favorable conditions and good husbandry. A two-years' rest in clover pastured on the ground and then plowed under, would greatly improve its fertility.

OHIO COUNTY.

No. 2397—MINERAL WATER: "*From a spring on the hillside, two miles from Haynesville and three miles from Fordsville—farm of J. M. Royal, on the Hartford and Hawesville road. Sample sent by J. M. Royal.*"

COMPOSITION, *in 1000 Parts of the Water.*

Iron and manganese carbonates	Small quantities not estimated.	Held in solution by carbonic acid.
Lime sulphate	0.938	
Magnesia sulphate	1.530	
Potash sulphate	.023	
Soda sulphate	.185	
Sodium chloride	.200	
Silica	.078	
Total saline matters	2.954	in 1000 parts of the water.

A good weak saline, chalybeate water.

PERRY COUNTY.

No. 2398—COAL: "*From J. H. Comb's bank, below and opposite Hazard. Bed three feet thick without parting. One hundred feet above the river. Collected by A. R. Crandall. Brought August 3, 1881.*"

A pure-looking, pitch-black splint coal. Shows very little fibrous coal and no visible pyrites between its irregular laminæ.

No. 2399—COAL: "*From the mouth of Sassafras creek. Average sample, from near the outcrop, from the whole face of the bed, of four and a half feet thickness, excluding two and a half inches of 'bone coal' near the middle. Collected by A. R. Crandall, July 13, 1883.*"

Generally a bright splint coal. No apparent pyrites and very little fibrous coal between its laminæ. Some little incrusting clay on some of the pieces, which will increase the ash percentage.

COMPOSITION OF THESE PERRY COUNTY COALS.

(Air-dried).

	No. 2397	No. 2398
Specific gravity	1.272	1.305
Hygroscopic moisture	1.50	1.30
Volatile combustible matters	36.10	34.70
Coke	62.40	64.00
Total	100.00	100.00
Total volatile matters	37.60	36.00
Fixed carbon in the coke	59.06	56.10
Ash	3.34	7.90
Total	100.00	100.00
Character of the Coke	Spongy.	Spongy.
Color of the ash	Light grey.	Buff-grey.
Percentage of sulphur	0.618	0.437

These are both good pure coals, more especially No. 2397. The apparent ash percentage of No. 2398 is no doubt increased by the adherent dirt in the sample. When the bed is opened out deeper the ash percentage will probably be found to be much less.

PIKE COUNTY.

"Elkhorn Coals" (so-called).

No. 2399—COAL: *"On Big Elkhorn. Seven feet bed, with a two-inch parting six inches above the middle. Sample of an average of the whole bed Collected by A. R. Crandall, November 12, 1881."*

A firm, pitch-black, pure-looking coal, showing very little fibrous coal and no apparent pyrites.

No. 2400—COAL: *"From Isaac Patton's new bed, on branch, head of Elkhorn creek. Two feet thick or more. Collected by A. R. Crandall, November, 1881."*

A pure-looking, pitch-black coal. Shows but little fibrous coal or granular pyrites.

No. 2401—COAL: "*On Big Elkhorn creek, at Mullen's branch, head of Kentucky river. Bed nearly four feet thick. Average sample of the lower part. Collected by A. R. Crandall, November 12, 1881.*"

Resembles the next preceding.

No. 2402—COAL: "*Elkhorn coking coal. (Rice's coal.) On Mill branch of Elkhorn creek. (Coal No. 1?) Whole thickness one hundred and one inches. (Sample I.) From lower forty-four inches. Collected by Roger C. Ballard, August 28, 1882.*"

A pure-looking, pitch-black coal, breaking easily; fracture generally irregular cuboidal. No appearance of pyrites or fibrous coal. (Some portions of this coal were light enough to float on water, so that its specific gravity was taken by the use of alcohol.

No. 2403—COAL: "*From same bed. Sample II. (of the upper part of the bed), etc., etc.*

Resembles the preceding.

No. 2404—COAL: "*Slack Coal, from Elkhorn creek of Big Sandy, from which the coke No. 2413 was made at Connellsville, Pa.*"

No. 2405—COAL: "*From Cane branch of Elkhorn creek. Geological position, 'Main coal.' Sample from the upper five feet five and a half inches, above the six-inch parting. Collected by A. R. Crandall, August 22, 1883.*"

A bright, pure-looking, soft coal, with very little appearance of fibrous coal or pyrites. A very free burning coal.

No. 2406—COAL: "*From the same bed as the next preceding. Sample from the lower three feet seven inches. Collected by A. R. Crandall, August 22, 1883.*"

Resembles the next preceding.

No. 2406 A—BONE COAL (SO-CALLED): "*From the lower stratum of the above. Collected by A. R. Crandall, August 22, 1883.*"

Resembles a splint coal. This gave a dense friable coke, and left only 4.40 per cent. of very light buff ash.

COMPOSITION OF THESE PIKE COUNTY ELKHORN COALS.

(*Air-dried*).

	No. 2399	No. 2400	No. 2401	No. 2402	No. 2403	No. 2404	No. 2405	No. 2406
Specific gravity	1.282	1.307	1.271	1.278	1.271	n. e.	1.355	1.314
Hygroscopic moisture	2.60	2.60	2.00	1.60	1.60	1.80	6.00	2.54
Volatile combustible matters	34.20	33.40	33.50	32.10	29.36	26.80	31.26	32.26
Coke	63.20	64.00	64.50	66.30	69.04	71.40	62.74	65.20
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	36.80	36.00	35.50	33.70	30.96	28.60	37.26	34.80
Fixed carbon in the coke	60.80	61.30	60.54	64.64	67.40	67.60	59.34	62.20
Ash	2.40	2.70	3.96	1.66	1.64	3.80	3.40	3.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Dense.	Dense.	Light Spongy.	Very lt. Spongy.	Inflated.	Dense Spongy.	Pulverulent.	Dense, hard.
Color of the ash	Light buff.	Light buff.	Light grey.	Lt. reddish-br.	Lt. reddish-br	Brownish-red.	Lt.fawn col'd.	Lt.pu .- buff.
Percentage of sulphur	.412	.467	.429	.711	.610	.967	.390	.547

Remarkably good coals, containing but small proportions of ash and sulphur. The "slack coal," No. 2404, of course contains more of these ingredients than most of the others.

From the Coke Report of F. Platt, Second Geological Survey of Pennsylvania, Special Report L, 1875, p. 120, we for comparison give the analysis of "three types of the best coking coals of Pennsylvania," including that of the celebrated Connellsville coal, as follows:

	a Connellsv'e.	*b* Bennington.	Broad Top.	
	Pitts'g Seam.	Miller.	*b* Barnett.	*c* Miller.
Volatile matters	81.360	22.380	16.00	19.68
Fixed carbon	59.620	68.500	74.65	71.12
Ash	8.230	8.000	7.50	7.50
Sulphur	.784	1.120	1.85	1.70
Total	99.994	100.000	100.00	100.00
Coke	68.000	76.000	81.00	78.00

Analysts—*a*, McCreath. *b*, *c*, T. T. Morall.

According to F. Platt, the requirements of a good coking coal are as follow:

"1. Pure semi-bituminous coal.

"2. Must contain enough volatile matters to supply heat in coking without expenditure of carbon.

"3. Its coke must be tenacious enough to sustain, without crumbling, the burthen and blast of the furnace, and have an open cellular structure to facilitate its penetration by the carbonic acid gas in the furnace."

It will be seen that the Elkhorn coal and other coals of Kentucky compare very favorably with these celebrated Pennsylvania coals.

Other Pike County Coals.

No. 2407—COAL: "*From Stone Coal creek, four and a half miles below Pikeville. Upper two feet eight inches. Average sample. Collected by A. R. Crandall, September 4, 1882.*"

A pure-looking, pitch-black coal. Some portions showing scales of bright pyrites and fibrous coal. One portion has irregular fracture; another portion breaks into irregular laminæ.

No. 2408—COAL: "*From the same bed. Average sample from the lower three feet. Collected by A. R. Crandall, September 4, 1882.*"

A considerable portion of the sample is in tough laminæ, and like cannel coal, of a dull black, showing fibrous coal between the layers; another portion is of bright pitch-black and of irregular fracture.

No. 2409—COAL: "*Head of Chloe creek, two miles and a half south of Pikeville. Average sample from the lower four feet eight inches. Entry driven thirty feet.*"

A pure-looking, pitch-black coal, showing very little fibrous coal and no apparent pyrites.

No. 2410—COAL: "*From three-quarters of a mile above Pikeville, on Little Chloe creek. An average sample from Sykes' bank. Collected by A. R. Crandall, September 3, 1882.*"

Mostly laminated, and showing a weathered appearance. Some little fibrous coal apparent, but no pyrites.

COMPOSITION OF THESE OTHER PIKE COUNTY COALS.

(*Air-dried.*)

	No. 2407	No. 2408	No. 2409	No. 2410
Specific gravity	1.279	1.293	1.273	1.367
Hygroscopic moisture	2.20	2.40	1.40	5.06
Volatile combustible matters	36.10	35.40	33.66	29.84
Coke	61.70	62.20	64.94	65.10
Total	100.00	100.00	100.00	100.00
Total volatile matters	38.30	37.80	35.06	34.90
Fixed carbon in the coke	58.10	58.26	58.60	57.50
Ash	3.60	3.94	6.34	7.60
Total	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Spongy.	Spongy.	Pulverulent.
Color of the ash	Lt. buff grey.	Lt. buff grey.	Lt. greyish.	Nearly white.
Percentage of sulphur	0.651	0.692	0.825	1.088

These also are good coals, containing generally only a little more sulphur and ash than the average Elkhorn coals. No. 2410 shows the effects of weathering in the increase of its moisture, ash, etc. The coal is no doubt purer deeper in the bed.

Elkhorn (Pike County) Cokes.

No. 2411—COKE: "*Made of the Elkhorn coking coal, from Elkhorn creek, six miles above the mouth of Mill branch. Rice's opening.*

No. 2412—COKE: "*Of the Elkhorn coal, made in an oven in Cincinnati. Sent by Mr. Jno. R. Procter, December 7, 1882, who wrote: 'I see some small bits of slate in the coke, which will doubtless make the percentage of ash larger than were the coal carefully mined.'*"

A firm, bright coke.

No. 2413—COKE: "*Made from the Elkhorn slack coal (No. 2404), coked at Connellsville, Pa., by inclosing the coal in a*

wooden box, nailed up, and putting it in the midst of the Connellsville coal in a coking oven. Sent from Cincinnati January 18, 1883, by H. W. Bates, Vice President of Eastern Railway Company."

This coke is bright and firm and of moderate porosity. (The specific gravity was taken of a lump.)

No. 2414—COKE: "*Of Elkhorn coal, Wm. Mullens, on Elkhorn creek. Made from a sample taken from the upper part of the bed. Sent by R. C. Ballard, September 8, 1883.*"

A firm columnar coke.

No. 2415—COKE: "*Of coal from the same bed. Made from a mixed sample of the coal. Sent by R. C. Ballard, September 5–10, 1883.*"

A little more porous than the preceding.

COMPOSITION OF THESE PIKE COUNTY (ELKHORN COAL) COKES.
(*Air-dried.*)

	No. 2411	No. 2412	No. 2413 *c*	No. 2414	No. 2415
Moisture, etc., lost on ignition	2.86*a*	0.20*b*	1.20	1.10	1.06
Fixed carbon in the coke	88.44	93.20	94.14	95.40	90.40
Ash	8.70	6.60	4.66	3.50	8.54
Total	100.00	100.00	100.00	100.00	100.00
Color of the ash	Lt. lilac grey.	Brown'h red.	Brown'h red.	D'k lilac grey.	Lt. purplish g'y.
Percentage of sulphur	0.844	0.734	1.484	0.517	0.598

(*a*) Moisture lost at 500° F.; (*b*) at 220° F. (*c*) Specific gravity 0.937.

Another sample of No. 2412 sent by Mr. Bates, gave on analysis, moisture 0.06 per cent., fixed carbon 94.34, brownish-red ash 5.60 and sulphur 0.788.

These cokes compare very favorably with the celebrated coke of Connellsville, Pa., which is exported to all parts of the country in immense quantities.*

**The Scientific American* of November 18, 1882, page 323, states, that eight thousand coke ovens are in use at Connellsville, of a daily capacity of 15,000 tons, and that the coke is prized because of its high proportion of carbon, its freedom from impurities, and its hardness. (See *Bell County* and a following page for the official analysis of the Connellsville Coke.)

Some experiments were made with Coke No. 2413 to ascertain its porosity; by first finding the cubic contents of a number of weighed fragments; by immersion in water in a specific gravity bottle; then placing them, immersed in water, in the vacuum of an air-pump for several hours, to remove the air from the pores and fill them with water; then, by weighing them again, after wiping dry the superfices, to ascertain the quantity of water absorbed into the pores, etc. In this imperfect manner the cell space was found to be 41.46 per cent. of the volume of the coke. As, in the first immersion of the coke, to get its cubic volume, some water necessarily entered its pores, this estimation is evidently only approximative.

In experiments made by the officers of the Second Pennsylvania Geological Survey (See F. Platt's Coke Report of 1875, Special Report L, p. 130), "the cellular space of coke was obtained by immersing an accurately cut cubic inch of the coke in a glass of distilled water under the receiver of an air-pump, exhausting the air and weighing the cube dry and wet, the difference indicating the cellular space, as the specific gravities of coke and water are very nearly alike." (Not always.)

According to that author, the best cokes have the cell space to the whole mass very nearly as one to two; but he states "these proportions can differ widely in cokes, giving equally good results in furnace use; 38 to 62 is obtained from a coke of a first-class order in strength and purity."

The much larger surface exposed to the penetrating water in the small fragments used in our experiments, as compared with that of the solid cubic inch used in the Pennsylvania determination, would expose more cells to be filled by the water, and hence increase the apparent cell space.

No. 2416—IRON ORE: "*On Elkhorn creek, sixteen miles from its mouth, at Levi Potter's, Pike county. One hundred and fifty feet above the bed of the creek. In large blocks. Average sample from a large block. Collected by A. R. Crandall, August 28, 1882.*"

A dark-colored, dull-brownish, cellular conglomerate or concretion.

COMPOSITION, *Dried at 212° F.*

Iron peroxide	59.630=41.74 per cent. of iron.
Alumina, etc.	7.927
Phosphoric acid (P_2O_5)	.563=0.284 per cent. of phosphorus.
Combined water	.560
Silicious residue	29.720 containing 21.98 per cent. of silica.
Undetermined and loss	1.600
Total	100.000

No. 2416 (*a*)—SO-CALLED "BRECCIATED OR DYE ORE." "*Sample from a large block on the surface. Mr. Gibson's place on Pigeon Roost branch, Pike county. Collected by A. R. Crandall, August 20, 1882.*"

A friable breccia, mainly of argillaceous material, colored more or less reddish brown with iron oxide, and mottled with grey material, involving numerous fragments of ferruginous and grey sandstone or shale and chert.

It contains too little iron oxide to be of value as an ore, and its finer, ochreous material is of too dull color to be of much value as a pigment.

No. 2416 (*b*)—"CLAY ORE," "DYE ORE," SO-CALLED: "*On Mr. Roberts' place on Jackson branch, Pike county. Overlying the place of the so-called brecciated ore of other localities. Collected by R. C. Ballard, August 27, 1882.*"

A bright red ochre or bole, slightly mottled with small yellowish-grey portions; friable, involving fragments of silicious-ferruginous shale, which are rounded on the edges; also some irregular fragments of greyish sandstone.

Some of this bole, exclusive of the silicious fragments, pulverized of a bright venetian-red color. No doubt if ground and washed from the silicious material it might serve for a pigment.

PULASKI COUNTY.

No. 2417—COAL: *From Childer's opening, Capt. Geary's land, branch near the head of Indian creek. Average sample. Bed thirty-three inches thick. Six inches of the top semi-cannel; a parting an inch from the top. Thick sandstone rock next above it. Collected by A. R. Crandall, May 24, 1880.*"

A firm, bright, pure-looking, pitch-black splint coal, showing ferruginous stains on some of the exterior surfaces. Breaks irregularly, some portions in irregular laminæ, with fibrous coal and reed-like impressions between. Some portions show a bird's-eye structure. Shows very little granular pyrites.

No. 2418—COAL: "*Forty-two inch coal, under a sandstone cliff. Head of Barren Fork of Indian creek, three and a half miles from Flat Rock station, on the Cincinnati Southern Railroad. Collected by A. R. Crandall.*"

Resembles the preceding. Shows a little bright pyrites.

No. 2419—COAL: "*Bird's-eye cannel coal, from near the head of Barren branch of Indian creek. Nine inches thick. The whole bed is thirty inches thick. Collected by A. R. Crandall.*

Quite a tough cannel coal, breaking irregularly, with a hackly fracture across the laminæ, and showing the bird's-eye structure in the direction of the very irregular laminæ. Some of the exterior surfaces much coated with reddish-brown ochreous material. Shows no fibrous coal and very little pyrites.

No. 2420—COAL: "*From the 'Big Vein Coal Company's mine,' between the Cincinnati Southern Railroad and the South Fork of Cumberland river. Average sample. Sent by Mr. Procter, May 8, 1882.*"

No. 2421—COAL: "*From the Barren Fork Coal Company, near Flat Rock station on the Cincinnati Southern Railroad. (Conglomerate?) Sample of the marketable coal (thirty-five and a half inches). There is also above in some places two to four inches of splint coal, and below ten to twelve inches of very slatey coal. Collected by R. C. Ballard, November 18, 1882.*"

A pure-looking, pitch-black coal. Some portions breaking with irregular and sub-cuboidal fracture with brilliant surfaces; other portions showing lamination, with some little fibrous coal. No apparent pyrites, except a very few granules in the fibrous coal.

No. 2422—COAL: "*From Flat Rock mines, Flat Rock Station on the Cincinnati Southern Railroad. Collected by R. C. Ballard, November 20, 1882. (This is from the mine, including slack and all.)*"

Mostly dull, and apparently weathered, and fine laminated, with fibrous coal between the laminæ. No bright pyrites apparent.

No. 2423—COAL: "*From Cumberland Coal Company, Greenwood. (Coal No. 1.) Collected by R. C. Ballard, November 23, 1882.*"

A firm, pure-looking, pitch-black coal, breaking generally into thin laminæ, with some little fibrous coal between, but no apparent pyrites, except some small bright scales on one portion. A splint coal, resembling so-called "block coal."

No. 2424—COAL: "*From Beaver Creek Coal Company. Entry No. 1. Lower twelve inches. Bed forty-eight inches thick. Conglomerate. Collected by R. C. Ballard, November 20, 1882.*"

Much of the sample is bright, pitch-black coal, with glossy, irregular sub-cuboidal fracture. A portion more dull, breaks into thin laminæ, with dense mineral charcoal between, and specks of bright pyrites.

No. 2425—COAL: "*From same bed. Entry No. 2. Conglomerate. Bed forty-six inches thick. Collected by R. C. Ballard, November 20, 1882.*"

A pure-looking, pitch-black coal. Sample contains more of that with irregular cuboidal fracture and glossy surfaces than the preceding one, and a smaller proportion of the dull thin laminated coal, etc.

No. 2426—COAL: "*From same bed. Entry 6. Conglomerate. Sample of the middle thirty-one inches. Collected by R. C. Ballard, November 20, 1882.*"

Sample firm "splint" or "block coal." Breaks into irregular thin laminæ, with but little mineral charcoal, and some little granular pyrites between.

No. 2427—COAL: "*Same bed. Entry 6. Conglomerate. Sample from the lower seventeen inches of the bed. Collected by R. C. Ballard, November 20, 1882.*"

Sample contains rather more of the laminated or splint coal than the next preceding samples. Some granular pyrites apparent and a little dense mineral charcoal between the thin irregular laminæ.

COMPOSITION OF THESE PULASKI COUNTY COALS. (AIR-DRIED).

	No. 2417	No. 2418	No. 2419	No. 2420	No. 2421	No. 2422	No. 2423	No. 2424	No. 2425	No. 2426	No. 2427
Specific gravity	1.309	1.354	1.294	1.236	1.312	1.315	1.315	1.425	1.372	1.314	1.323
Hygroscopic moisture	3.03	2.68	1.67	2.20	1.54	1.76	2.50	2.14	2.06	2.20	2.34
Volatile combustible matters	35.04	35.44	45.46	36.24	33.80	36.24	36.20	31.46	34.04	36.56	34.32
Coke	61.83	61.88	52.87	61.56	64.66	62.00	61.30	66.40	63.90	61.24	63.34
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	38.07	38.12	47.13	38.44	35.34	38.00	38.70	33.60	36.10	38.76	36.66
Fixed carbon in the coke	55.98	55.18	46.07	56.96	58.26	55.26	52.10	47.74	52.50	53.14	56.14
Ash	5.95	6.70	6.80	4.60	6.40	6.74	9.20	18.66	11.40	8.10	7.20
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Spongy.	Dense spongy.	Light spongy.	Light spongy.	Spongy.	Spongy.	Dense.	Dense spungy.	Light spongy.	Spongy.
Color of the ash	Grey.	Lt. lilac grey.	Lt.br'n'h yellow.	Lt. buff grey.	Light grey.	Light grey.	Lt. lilac grey.	Lt. lilac grey.	D'k lilac-grey.	Lilac-grey.	Lt. buff grey.
Percentage of sulphur	1.236	2.334	3.035	0.742	1.540	1.286	2.601	2.140	4.250	3.645	1.265

Except No. 2424, which has a large proportion of ash, all these coals are good for all ordinary purposes. Even this may be profitably used when the large ash residue does not prove objectionable. The sample analyzed was only from the lower twelve inches of the bed. For all uses where sulphur would be injurious all these coals which contain more than two per cent. of that substance would not probably be applicable.

No. 2427—MARLY SHALE: "*From south of the Cumberland river, on the line of the Cincinnati Southern Railroad. Collected by W. H. Pettus, October, 1880.*"

A very friable marlite, generally of a light-chocolate color. Adheres slightly to the tongue.

COMPOSITION (*Dried at 212° F.*)

Alumina and iron and manganese oxides	15.814	
Lime	8.475	
Magnesia	.542	
Phosphoric acid	a trace.	
Potash, extracted by acids	1.666	
Soda, extracted by acids	.033	
Combined water	4.927	
Carbonic acid and loss	8.608	
Silicious residue	69.940	containing potash, 2.360 containing soda, . .230
Total	100.000	

Total potash, 4.026 per cent., total soda, .268 per cent.

Notwithstanding the rather more than four per cent. of potash contained in this shale, it could not profitably be used as a fertilizer, because most of the potash is in firm chemical combination with the silicates, and the proportion of phosphoric acid is very small.

No. 2428—YELLOW OCHRE: "*From one mile north of Somerset. Collected by W. H. Pettus.*"

In friable lumps which are mottled with various tints, from light yellowish to slightly brownish yellow. The general tint is a good yellow-ochre color. It contains a considerable proportion of fine sand.

If it is in a very large deposit, where there are facilities for cheaply washing it, a cheap pigment might possibly be made of it.

ROWAN COUNTY.

No. 2429—SANDSTONE: "*From the base of the Waverley formation. Sample supplied by the Freestone Company; Tyler, President. Taken from quarry near Farmer's Station, on the Chesapeake & Ohio Railroad, thirty-five miles beyond Mt. Sterling. Brought by Mr. W. W. Monroe.*"

A fine-grained sandstone of a handsome light-grey color on the recently exposed surfaces, showing a few minute spangles of mica. Adheres to the tongue. Stained light ochreous and brownish on the weathered surfaces. Showing no fossil remains, but *Spirophyton cauda-galli* (Hall) on one of its surfaces. This rock is used in the construction of the new court house at Lexington.

Specific gravity about 2.50. (This is somewhat difficult to take in lump, because it absorbs water.)

COMPOSITION (*Air-dried*).

Sand and insoluble silicates,	93.128
Iron carbonate,	2.886
Lime carbonate,	.578
Magnesia carbonate,	.256
Alumina, phosphoric acid, etc.,	1.188
Moisture and loss,	2.514
Total,	100.000

A small cube of this rock, measuring little more than a cubic inch, weighed 44.760 grammes, air-dried.

Immersed in water for twenty-five minutes and wiped, it had gained	1.744	grammes.
Immersed for forty-eight hours more, it gained only	.314	" more.
In all	2.058	"

Equal to 4.59 per cent.

After thorough drying at 212° F. it weighed 44.009 grammes, having lost 0.757 grammes, equal to 1.02 per cent. of its original weight, which probably represented hygroscopic moisture evaporated at this temperature. Again immersed in water for four hours, it absorbed 2.5 grammes.

In Vol. 4, *Reports of the Kentucky Geological Survey, O. S., p. 252*, the present writer gave an analysis of another sample of this sandstone, from the mouth of Triplett creek, on Licking river, which contained somewhat less sand and more of the other ingredients than that described above; and in Vol. 3 of the same series the late Dr. D. D. Owen notices the rock in place, remarking: "There is an excellent opportunity of opening fine quarries of fine-grained knob freestone without much stripping. The ledges are from one foot eight to two feet or more, and appear to be of good quality, as they form bold projecting ledges along the declivities of the hills."[1]

That this freestone proves to be durable in masonry which has been exposed to the weather for several years, and presents such bold enduring outlines in its original ledges, seems inconsistent with the fact of its porosity and its property of absorbing water to a considerable amount on its fresh surfaces. Its composition, however, explains this apparent discrepancy.

It is composed of fine grains of transparent, colorless quartz—pure silica—united by a cement composed of carbonates of iron, lime and magnesia, with a little silicate of alumina, and, as already stated, is quite absorbent of water on its freshly exposed surfaces; but the exterior surfaces of the bed or rock, which have been exposed for some time to the atmospheric agencies, are less porous and absorb much less water. The rock is comparatively soft and easily worked when fresh from the quarry, but it becomes harder and less porous in the course of time when exposed to the weather, its color changing at the same time to a light buff or a light brownish tint on the exposed surfaces.

These changes depend on the chemical properties of the cementing material of the stone. The carbonates which mainly compose this cement are to a certain extent soluble in the atmospheric water, which contains free carbonic acid, and which dissolves and holds them in solution as bicarbonates. But when this watery solution evaporates on the surface of the rock, the free carbonic acid and that of the bicarbonate of iron escapes and is replaced by oxygen and water; so that a hydrated per-

oxide of iron, mixed with the alumina and the carbonates of lime and magnesia, is formed on the surface, which gradually fills up the pores and is not soluble to any extent in water, thus increasing the superficial hardness of the stone and its power of withstanding the action of the elements.

This stone is of the same formation as that of the quarries of Berea, which is much used for constructions of various kinds.

SHELBY COUNTY.

No. 2430—VIRGIN SOIL: "*From the farm of John Davis, two miles east of Shelbyville. (Same as the soil from John Glen's.) Timber: Maple, walnut, yellow poplar, blue ash, white oak and white elm. Geological position, lower part of the upper Hudson river beds. Collected by W. M. Linney.*"

The dried soil is of umber-grey or dark-drab color. In friable clods.

The coarse seive removed from it about 3.5 per cent. of shot-iron ore. The silicious residue from digestion in acids all passed through the fine seive after crushing the small soft concretions which it contained.

No. 2431—SURFACE SOIL: "*From a field which had been cultivated for some years and then set in grass. Farm of John Davis, etc., etc. (Same locality as the next preceding.) Collected by W. M. Linney.*"

Soil darker colored than the preceding. Light snuff colored. Quite friable.

The coarse seive removed from it a very small proportion of shot-iron ore. The silicious residue of this left a considerable proportion of small rounded concretions of partly decomposed silicates, soft enough to be crushed under the finger, when all passed through the fine seive when thus crushed.

No. 2432—SOIL: "*Mixed to the depth of ten inches, from a field over twenty years in cultivation, on the farm of John Glen, two miles east of Shelbyville. Same geological position as the preceding. Collected by W. M. Linney.*"

This soil resembles the next preceding in color, but is slightly lighter colored. Clods more firm than of that.

The coarse seive removed a very small proportion of shot-iron ore. Its silicious residue was like that of the preceding."

No. 2433—VIRGIN SOIL: "*From the top of the upper Hudson river beds, five miles east of Shelbyville. Timber: Walnut, white and red oak, elm and honey locust. Collected by W. M. Linney.*"

Soil of a dark-brown color, containing fossil shells and portions of Chætetes. Clods quite firm.

The coarse seive removed 8.2 per cent. of calcareous fossil remains. The silicious residue resembled that of the preceding. Concretions harder.

No. 2434—SOIL: "*From an old field. Same locality as the next preceding. Collected by W. M. Linney.*"

Soil in very firm clods, of a brownish-buff or drab color. The coarse seive removed a very small proportion of shot-iron ore. On the fine seive the silicious residue was similar to the preceding.

No. 2435—SUBSOIL: "*Of the next preceding, taken one foot to fourteen inches below the surface. Collected by W. M. Linney.*"

Subsoil of a light dirty brown color, lighter color than No. 2473. The firm clods contain many fragments of calcareous fossils, limestone fragments and shot-iron ore, of which the coarse seive removed 41.2 per cent. On the fine seive the silicious residue resembled the preceding, all finally passing through it.

No. 2436—VIRGIN SOIL: "*From Jeptha Knobs, five miles south-east of Shelbyville. Upper silurian formation. Collected by W. M. Linney.*"

Dried soil of a brownish drab color. Clods quite firm. The coarse seive removed about 18 per cent. of silicious and ferruginous fragments. On the fine seive the silicious residue resembled the preceding.

COMPOSITION OF THESE SHELBY COUNTY SOILS.

(*Dried at 212° F.*)

	No. 2430	No. 2431	No. 2432	No. 2433	No. 2434	No. 2435	No. 2436
Organic and volatile matters	5.000	4.840	4.250	14.075	4.970	11.315	5.015
Alumina and iron and manganese oxides	9.044	8.852	9.494	16.158	9.490	14.380	6.590
Lime carbonate	.320	.645	.420	4.695	.720	25.245	.245
Magnesia	.298	.322	.247	1.373	.389	.805	.250
Phosphoric acid (P2 05)	.268	.268	.211	.412	.365	.415	.230
Potash (K2 O) extracted by acids	.347	.418	.384	2.015	.591	1.772	.256
Soda (Na2 O) extracted by acids	.062	.061	.000	.000	.064	trace.	.000
Water expelled at 380° F.	.515	.420	.365	.750	.280	.315	.570
Sand and insoluble silicates	83.995	83.945	84.245	61.045	83.310	47.295	86.545
Total	99.857	99.771	99.616	100.523	100.179	101.542	99.701
Hygroscopic moisture	1.885	1.865	1.635	4.125	1.800	2.520	1.165
Potash in the insoluble silicates	1.773	1.385	1.429	2.131	1.509	1.677	1.401
Soda in the insoluble silicates	.473	.348	.382	.150	.241	.075	.383
Rock fragments or concretions	3.500	....	....	8.200	....	41.200	18.000
Character of the soil	Virgin soil.	Cultiv'd field.	Cultiv'd field.	Virgin soil.	Old field soil.	Subsoil.	Virgin soil.

All of these soils contain more than the average proportions of essential mineral plant food, and would be classed among the very fertile soils if all other conditions are favorable. Nos. 2433 and 2435 excel especially in their very large proportions of organic and volatile matters, phosphoric acid and potash. They are also quite calcareous, especially No. 2435, which approaches the marls in this respect. They contain more alumina and oxide of iron than any of the other soils, and a smaller quantity of sand and soluble silicates. They are to be discounted, however, with the percentage of rocky fragments and fragments of fossil remains they contain.

No. 2437—LIMESTONE ROCK: "*From the Jeptha Knobs, five miles southeast of Shelbyville. Upper silurian formation. Supposed to be from the horizon of the Louisville cement rock. Collected by W. M. Linney.*"

A fine granular rock of a dull olive-grey color. Adheres to the tongue.

COMPOSITION (*Air-dried*).

Lime carbonate	40.780	equal to 22.837 per cent. of lime.
Magnesia carbonate	24.511	
Alumina and oxide of iron, etc.	5.917	
Phosphoric acid (P2 05)	.563	
Sulphuric acid (SO3)	.941	
Silicious residue	25.120	
Moisture, alkalies, loss, etc.	2.168	
Total	100.000	

It would probably yield a rich soil on disintegration by weathering.

The composition of this rock closely resembles that of the hydraulic limestone at the Falls of the Ohio in Jefferson county, an analysis of which was given in Vol. 2 of Old Series of Reports of the Geological Survey of Kentucky, p. 220, published in 1857.

For comparison the analysis of the Jefferson county rock and that of Jephtha Knobs, calculated as dried at 212° F., is here given:

	Jeptha Knobs Rock.	Jefferson County Rock.
Lime, carbonate	41.612	50.480
Magnesia, carbonate	25.010	18.670
Alumina and oxides of iron and manganese	6.378	2.930
Phosphoric acid (P2 O5)	.564	.060
Sulphuric acid (SO8)	.960	1.580
Potash	n. e.	.320
Soda	n. e.	.130
Silica and insoluble silicates	25.521	25.780

There is but little doubt that this rock would give a good hydraulic cement on proper calcination.

SPENCER COUNTY.

No. 2438—PHOSPHATIC LIMESTONE: "*From the lower part of the upper Hudson River beds. Collected by W. M. Linney, received July 5, 1883. Timber: Blue ash, walnut, chinquepin, oak (quercus prunus), wild cherry, hackberry, etc.*"

A coarse-grained semi-crystalline rock; grey, mottled with yellowish-brown, or ferruginous. Containing many broken organic remains.

COMPOSITION (*Air-dried*).

Lime carbonate	87.820	=48.889 per cent. of lime.
Magnesia carbonate	.787	
Alumina and iron oxide	2.478	
Phosphoric acid (P2 O5)	1.842	
Potash	.154	
Soda	.212	
Silicious residue	1.680	
Moisture, loss, etc.	5.527	
Total	100.000	

Contains more than the ordinary proportion of phosphoric acid, and would yield a fertile soil on disintegration.

No. 2439.—SOIL: "*Of an old field which has been in cultivation about seventy-five years. Eight inches of the surface soil on D. B. Wigginton's farm, two miles north of Fairfield. Geological position, upper Hudson river beds, near the top of the Lynx beds.*" *Collected by W. M. Linney. Received July 5, 1883.*

Soil with friable clods; of a light-grey-brown color. All passed through the coarse seive except a very small quantity of small ferruginous concretions. Its silicious residue all passed through the fine seive.

No. 2440—SUBSOIL: "*Ten inches. On the same farm as the preceding.*

Subsoil of a brownish-buff color; lighter colored than the preceding. Clods more firm. All passed through the coarse seive except a very small quantity of small ferruginous concretions. Its silicious residue all passed through the fine seive except two or three very small quartzose particles.

COMPOSITION OF THESE SPENCER COUNTY SOILS.

(*Dried at 212° F.*)

	No. 2439	No. 2440
Organic and volatile matters	3.550	3.205
Alumina and iron and manganese oxides	7.809	11.849
Lime carbonate	.320	.295
Magnesia	.250	.274
Phosphoric acid (P2 O5)	.236	.221
Potash (K2 O) extracted by acids	.228	.470
Soda (Na2 O) extracted by acids	.192	.117
Water, expelled at 380° F.	.727	.830
Sand and insoluble silicates	86.175	82.820
Total	99.487	99.581
Hygroscopic moisture	1.850	2.875
Potash in the insoluble silicates	1.068	1.206
Soda in the insoluble silicates	.473	.884
Rock fragments in the soil	.000	.000
Character of the soil	Old field soil.	Subsoil.

Notwithstanding the long time during which this soil has

been in cultivation, it yet retains more than average proportions of most of the essential mineral elements of fertility. It is somewhat deficient in organic matters—*humus*—and would be benefited by rest in clover, which, after being pastured for two years, should be plowed under.

WHITLEY COUNTY.

No. 2441—COAL: "*From the land of J. R. Ryan, on Marsh creek, near the line of Whitley county, Ky., and Scott county, Tenn. Sample from the mouth of the mine, taken from different parts of the bed, which is thirty-six inches thick. Collected by W. C. Crozier. Received June, 1882.*

A glossy, pitch-black, pure-looking coal, showing very little fibrous coal or granular pyrites. Softens and swells into a light spongy coke when heated.

No. 2442—COAL: "*From Bryvan's opening, on Worley branch of the South Fork of the Cumberland river. Conglomerate coal. Collected by R. C. Ballard, November 17, 1882. Upper part of the coal fifty-five inches thick. It was from this that the coke was made.*"

A pure-looking coal; fracture mostly irregular cuboidal, with shining surfaces; partly breaking into thin laminæ, with more or less fibrous coal between. No apparent pyrites.

No. 2443—COAL: "*From Devil's Jump opening, on the South Fork of Cumberland river. Bryvan's coal; conglomerate series. This sample is of the forty-six inches opened up. The ten inches of coal below it is not included. Collected by R. C. Ballard, November 16, 1882.*"

Resembles the next preceding.

No. 2444—COAL: "*From Bryvan's opening, Worley branch of South Fork of Cumberland river. Conglomerate. Lower part of the bed, fourteen inches. Collected by R. C. Ballard, November 17, 1882.*"

Appears to have more of the laminated coal than the preceding and more fibrous coal, but no apparent pyrites.

No. 2445—COAL: "*From Bryvan's Coal Company, etc., etc. Collected by R. C. Ballard, November 16, 1882.*"

Resembles No. 2442; fracture generally irregular, with shining surfaces. Very little fibrous coal, and no apparent pyrites.

No. 2446—COAL: "*From J. S. Berry's, five miles north of Williamsburg, one mile north of Mahon's Station. Sample from the lowest twenty-two inches of the fifty-six-inch bed. Collected by R. C. Ballard, October 2, 1882.*

A firm, pitch-black, pure-looking coal, generally breaking with irregular shining surfaces. Some little fibrous coal on some of the pieces.

No. 2447—COAL: "*From the same locality as the next preceding. Sample from the upper seam of twenty-six inches. Collected by R. C. Ballard, October 26, 1882.*"

A firm, pitch-black coal, breaking into irregular laminæ with generally shining irregular surfaces. Somewhat cuboidal in its large fracture. Very little fibrous coal apparent.

COMPOSITION OF THESE WHITLEY COUNTY COALS.

(*Air-dried.*)

	No. 2441	No. 2442	No. 2443	No. 2444	No. 2445	No. 2446	No. 2447
Specific gravity . . .	1.275	1.295	1.306	1.368	1.321	1.254	1.289
Hygroscopic moisture .	2.08	1.40	0.94	1.34	1.50	2.00	2.00
Volatile comb. matters	35.58	36.74	39.86	33.06	39.40	34.54	33.40
Coke	62.34	61.86	59.20	65.60	59.10	63.46	64.60
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters .	37.66	38.14	40.80	34.40	40.90	36.54	35.40
Fixed carb. in the coke	58.90	54.20	47.30	53.88	53.70	61.92	61.90
Ash	3.44	7.66	11.90	11.72	5.40	1.54	2.70
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Light Spongy.	Spongy.	Dense Spongy.	Spongy.	Spongy.	Light Spongy.
Color of the ash . .	Lt.yel'h-grey.	Brow'h-grey.	Lt. grey-brown.	Nearly white.	Brow'h-grey.	Lt.fawn-colored.	Light buff.
Percentage of sulphur	0.567	1.201	3.741	0.555	1.089	0.830	0.637

In these coals the ash percentage varies from 1.54 in No. 2446 up to 11.72 and 11.90 in Nos. 2444 and 2443, and the sulphur from 0.555 in No. 2444 up to 3.741 in No. 2443, which is exceptional in this respect and may be accidental, owing possibly to some pyrites in the sample which might probably be excluded. With the exception of those which exceed in ash and sulphur, the coals are very good, and even these are valuable for most ordinary uses.

No. 2448—COKE: "*Made of Coal (A), or the lowest of this series. From the mouth of Worley; South Fork of Cumberland river; Captain Crozier's mines. Sub-conglomerate. Collected by R. C. Ballard, November 18, 1882. This was made from the upper part of the bed and was coked in August at Rockwood, Tenn., in a box placed in an oven.*"

A firm, compact coke.

No. 2449—COKE: "*Of J. S. Berry's coal, five miles north of Williamsburg, one mile north of Mahon's Station. Collected by R. C. Ballard, October 2, 1882. Coke made of the coal of the entire bed.*"

A bright, firm coke, moderately porous.

COMPOSITION OF THESE WHITLEY COUNTY COKES.

(*Air-dried.*)

	No. 2448	No. 2449
Moisture, etc., expelled at red heat	2.10	4.80
Fixed carbon in the coke	90.46	92.60
Ash	7.44	2.60
Total	100.00	100.00
Color of the ash	Chestnut brown.	Lt. br'nish gr'y.
Percentage of sulphur	0.665	0.665

No. 2449 is a remarkably pure coke. No. 2448, containing more ash material, is not quite so valuable in equal weights. Its rather large proportion of moisture and volatile matters may be only accidental.

No. 2450—Iron Ore: "*From J. S. Berry's, five miles north of Williamsburg, one mile north of Mahon Station. Collected by R. C. Ballard, October 28, 1882.*"

Mostly concretions of impure concentric limonite layers, or irregular forms of the same, frequently with an internal cavity. Color from dark-brown to ochreous.

Composition (*Air-dried.*)

Iron peroxide	63.380=44.36 per cent. of iron.
Alumina	8.776
Lime and magnesia	Traces.
Phosphoric acid (P_2O_5)	.946
Silica	15.280
Carbonic acid, water, etc., etc	16.618
Total	100.000

Although it contains more than average phosphoric acid, this ore might be available for iron production if it is found in sufficiently large quantities and under other favorable conditions.

WOODFORD COUNTY.

No. 2451—Mineral Water: "*Sulphur water from a well bored seventy feet deep, on the farm of Mr. Charles Alexander, a mile and a half from Versailles. Water brought up in a sand bucket.*"

The water, when brought to the laboratory had a yellowish color and a strong smell and taste of sulphides. Evaporated to dryness at 212° F., it left 7.124 parts per 1000 of saline matters, which were found to consist of bicarbonates of lime, magnesia, soda, and a small proportion of lithia; sulphates of potash, lime and magnesia; chlorides of sodium, calcium and magnesium, with traces of bromides and iodides, a notable quantity of sodium sulphide and a small trace of strontia. In short, it resembles the Blue Lick water in composition. A quantitative analysis was not made of it, and its proportions of hydrogen sulphide and carbonic acid gases were not ascertained.

APPENDIX.

For the sake of comparison with our Kentucky coals, some analyses, made at the Laboratory of the Survey of coals from other States are here appended.

ALABAMA.

No. 2452—COAL: "*From Gaines' bed, Wolfe creek, Walker county, Alabama. Sample of the bed taken by Jno. R. Procter.*"

A pure-looking, pitch-black coal, breaking generally with shining fracture. Shows very little fibrous coal and no apparent pyrites.

No. 2453—COAL: "*From Mt. Carmel bed, one hundred yards from Mt. Carmel Church, Walker county, Alabama. Sample of the bed by J. R. Procter, February 1, 1883.*"

A remarkably bright, pitch-black coal. Has very little fibrous coal between its laminæ and no appearance of pyrites.

No. 2454—COAL: "*From the Townley bed. Sample from the top of the bed above the four feet parting. Sampled by J. R. Procter, February 2, 1883.*"

Generally breaking into thin laminæ, with some little fibrous coal between, but no appearance of pyrites.

COMPOSITION OF THESE ALABAMA COALS.

(*Air-dried.*)

	No. 2452	No. 2453	No. 2454
Specific gravity	1.259	1.307	1.351
Hygroscopic moisture	1.30	1.34	1.94
Volatile combustible matters	37.10	29.76	30.46
Coke	61.60	68.90	67.60
Total	100.00	100.00	100.00
Total volatile matters	38.40	31.10	32.40
Fixed carbon in the coke	54.46	58.10	55.04
Ash	7 14	10.80	12.56
Total	100.00	100.00	100.00
Character of the coke	Light spongy.	Light spongy.	Dense friable.
Color of the ash	Grey-buff.	Light buff.	Very li't buff.
Percentage of sulphur	1.425	0.665	0.473

Nos. 2453 and 2454 exceed the general average of ash proportion; otherwise all these coals could be classed with the best, for all ordinary uses.

TENNESSEE COALS.

No. 2455—COAL: "*From Jellico Mountain Coal and Coke Company's mine, Emmett, Campbell county, Tennessee. Five feet bed. Sample from the lower layer, which is two to two and a half feet thick. Analyzed for Col. S. L. Wooldridge, President of the Company, April 11, 1882.*"

A bright, pure-looking coal, showing very little pyrites or fibrous coal. Firm, so that it may be mined in large blocks. Fracture shining on all the faces. Small shining facets irregularly disposed on some of the cross fractures, approaching what is called bird's-eye structure.

No. 2456—COAL: "*From the same Company's mines. Mine on*

Crooked creek, Campbell county, Tennessee. Sample collected by R. C. Ballard, November 8, 1882."

Generally jet-black, breaking with irregular glossy surfaces; some portions with small bird's-eye structure; other portions dull-black, and breaking into laminæ, showing some granular pyrites, but very little fibrous coal.

No. 2457—COAL: "*From the same locality. Collected by R. C. Ballard, November 7, 1882. Coal twenty-two inches thick; one hundred and seven inches below the main seam.*"

Resembles the darker and brighter portions of the next preceding sample.

COMPOSITION OF THESE TENNESSEE COALS.

(*Air-dried.*)

	No. 2455	No. 2456	No. 2457
Specific gravity	1.256	1.311	1.289
Hygroscopic moisture	2.36	2.10	2.90
Volatile combustible matters	35.44	30.84	33.80
Coke	62.20	67.06	63.30
Total	100.00	100.00	100.00
Total volatile matters	37.80	32.94	36.70
Fixed carbon in the coke	60.60	61.56	61.80
Ash	1.60	5.50	1.50
Total	100.00	100.00	108.00
Character of the coke	Spongy.	Dense.	Dense Spongy.
Color of the ash	Salmon-color.	Brow'h-grey.	Lt.yel'h-brown.
Percentage of sulphur	1.162	2.285	.670

These are all very good coals. No. 2457 has a remarkably small proportion of ash, and contains less than the average amount of sulphur. No. 2455 also gives a very small quantity of ash. No. 2456 contains more than the average amount of sulphur.

No. 2458—COKE: "*From the Jellico Mountain Coal and Coke Company mine. Upper layer, etc., etc. Collected by R. C. Ballard.*"

A bright, firm coke; quite porous.

No. 2459—COKE: "*From same mine; lower layer.*"

A bright, firm coke; seems somewhat more dense than the preceding.

COMPOSITION OF THESE JELLICO MOUNTAIN COAL AND COKE COMPANY'S COKES. (*Air-dried.*)

	No. 2458	No. 2459
Moisture, expelled at 220° F.	2.90	3.70
Volatile matters expelled at red heat	1.10	1.00
Fixed carbon in the coke	91.80	92.60
Light yellowish-brownish ash	4.20	2.70
Total	100.00	100.00
Percentage of sulphur	1.027	.725

These are remarkably pure cokes, equaling in this respect the best samples of the Kentucky Elkhorn coke and the celebrated Connellsville coke of Pennsylvania. They have doubtless been made of the pure coal of the mine, and not of the slack coal, which is always more impure.

(See, under the head of Carter county, the analysis of a cannel coal from West Virginia.)

TABLE I.—SOILS AND SUBSOILS. (DRIED AT 212° F.)

Number	County.	Organic and volatile matter.	Alumina, iron oxide, etc.	Lime carbonate.	Magnesia.	Phosphoric acid (P_2O_5)	Potash extracted by acids	Soda extracted by acids	Water expelled at 380° F.	Sand and insoluble silicates.	Moisture expelled at 212° F.	Potash in insoluble silicates.	Soda in insoluble silicates.	Rock fragments or gravel	Remarks.
2386	Morgan	6.595	8.420	0.325	0.718	0.155	0.236	. . . .	1.570	82.170	2.415	2.384	0.350	37.730	Virgin soil; woods; Shaw's ck, nr. L'king r.
2387	Morgan	4.239	6.577	.120	.699	.118	.153	.308	.835	87.570	1.600	2.757	.380	13.000	Subsoil of the same.
2388	Morgan	3.305	3.655	.335	.412	.115	.104	.156	.810	91.450	1.150	1.727	.490	2.310	Soil, old field; bottom land, near Licking r.
2389	Morgan	2.650	4.121	.245	.282	.121	.043	.071	.600	91.682	.960	1.911	.410	2.110	Subsoil of the same.
2390	Morgan	3.115	3.505	.170	.261	.140	.082	. . . .	.860	91.485	.855	1.410	.316	11.850	Old-field soil; 2 m. sb. W. Lib'y, nr Lick'g r.
2391	Morgan	3.225	5.262	.120	.299	.108	.121	. . . .	.625	90.180	1.115	1.723	.286	.510	Subsoil of the same.
2396	Nelson	3.020	9.772	.145	.305	.173	.438	. . . .	.612	84.820	2.350	1.200	.646	. . . .	Fm S. P. Stiles; very old field; 4 m. n. Bds'n
2430	Shelby	5.060	9.041	.320	.286	.268	.347	.082	.515	83.905	1.855	1.773	.473	8.500	Virgin soil; Jno. Davis', 2 m. e. Shelbyville.
2431	Shelby	4.810	8.852	.615	.322	.268	.418	.061	.420	83.945	1.865	1.385	.348	. . . .	From a cultivated field 2 m. e. Shelbyville.
2432	Shelby	4.250	9.491	.420	.247	.211	.384	.000	.365	84.245	1.635	1.429	.382	. . . .	From a field 30 yrs in cultiv'n; John Glen's.
2433	Shelby	14.075	16.158	4.605	1.373	.412	2.015	.000	.750	61.045	4.125	2.131	.150	8.200	Virgin soil; top upper Hudson river beds.
2434	Shelby	4.970	9.490	.720	.389	.305	.591	.064	.280	83.310	1.800	1.509	.241	. . . .	From an old field, same locality.
2435	Shelby	11.315	14.380	25.245	.805	.415	1.772	trace.	.315	47.295	2.520	1.677	.075	41.200	Subsoil of next preceding.
2436	Shelby	5.015	6.590	.215	.250	.230	.256	.000	.570	86.545	1.165	1.401	.383	18.000	Virgin soil; Jeptha Knobs; up. silurian.
2439	Spencer	3.550	7.809	.320	.250	.236	.228	.192	.727	86.175	1.850	1.063	.473	.000	Soil of 75 yr-old field 2 m. n. of Fairfield.
2440	Spencer	3.265	11.849	.295	.271	.221	.470	.117	.830	82.320	2.875	1.206	.384	.000	Subsoil of same; D. B. Wigginton's.

TABLE II.—COALS. (AIR-DRIED.)

Number	County.	Specific gravity	Hygroscopic moisture	Volatile combustible matter	Coke.	Total volatile matters	Fixed carbon in the coke	Ash.	Character of the coke	Color of the ash	Percentage of sulphur	Remarks.
2264	Bell	1.344	1.00	32.70	66.30	33.70	52.80	13.50	Light spongy	Lt. choc'te-grey	2.115	J. Killam's coal.
2265	Bell	1.241	1.00	37.46	61.54	38.46	60.48	1.06	Spongy	Salmon colored	0.503	Coal near house of B. G. Rice, on Caney f'k.
2266	Bell	1.254	1.10	36.44	62.46	37.54	59.66	2.80	Spongy	Lt. choc'te-grey	0.613	Coal, Daniel Howard's, on Caney fork.
2267	Bell	1.270	0.86	36.04	63.10	36.90	59.20	3.90	Light spongy	Brown'h li'c-g'y	2.032	Coal, Fred. Burner's bank, Yellow creek.
2268	Bell	1.281	0.86	35.60	63.54	36.46	57.88	5.66	Light spongy	Brown'h li'c-g'y	2.454	Coal from same locality.
2282	Breathitt	1.212	1.60	46.60	51.80	48.20	46.80	5.00	Dense spongy	Lt. brown'h-g'y	.824	Haddock's cannel coal.
2283	Carter	1.299	6.30	35.54	58.16	41.84	54.82	3.34	Spongy	Lt. choc'te-grey	.881	Coal No. 7, Coalton coal; Straight Creek Co.
2284	Carter	1.291	2.80	51.20	46.00	54.00	35.30	10.70	Pulverulent	Grey buff	.753	Herrin's cannel coal, on Sinking creek.
2285	Carter	1.203	1.46	54.74	43.80	56.20	33.80	10.00	Dense friable	Light buff-grey	1.274	Cannel coal, Aden Station, Brent's.
2286	Carter	1.634	2.04	25.86	72.10	27.90	32.10	40.00	Pulverulent	Light buff-grey	0.731	Cannel coal, or bituminous shale, Aden's St'n.
2287	Carter	1.233	1.46	54.04	44.50	55.50	34.76	9.74	Dense friable	Lilac grey	2.164	Cannel coal, Little Sandy R., Parson's.
2291	Elliott	1.388	2.10	41.34	56.56	43.44	35.96	20.60	Dense	Light lilac-grey	1.150	Cannel coal, Buck f. of Mid. f. Lit. San. r.
2297	Floyd	1.302	2.04	37.42	60.54	39.46	56.31	4.20	Spongy	Lilac colored	1.475	From mouth of Mud creek; upper 18 inc's.
2298	Floyd	1.281	2.10	37.16	60.74	39.26	57.74	3.00	Spongy	Nearly white	.596	From same bed; lower 3 feet 5 inches.
2299	Floyd	1.350	1.30	36.70	62.00	38.00	51.70	10.30	Spongy	Light lilac-grey	1.356	From Laynesville, middle of upper part.
2300	Floyd	1.284	1.90	35.30	62.80	37.20	58.94	3.86	Spongy	Light grey	.715	From same; lower 45 inches.
2301	Floyd	1.523	2.50	32.50	65.00	35.00	56.54	8.46	Dense spongy	Light grey	.651	From mouth of Steel cr.; av. of upper 4 ft.
2302	Floyd	1.350	3.80	33.80	62.40	37.60	60.60	1.80	Pulverulent	Reddish buff	.175	From Flemming's or Jack's cr.; new outc'p.
2327	Johnson	1.279	3.00	49.80	47.20	52.80	37.94	9.26	Dense	Lt. gray-brown	2.009	Cannel coal, Smith's br. of Paint creek.
2328	Johnson	1.248	1.80	49.10	49.10	50.90	41.16	7.94	Dense friable	Lt. buff-grey	.816	Can. c'l, 1 m. n. m'th Lit. P't cr.; up. 22 in.
2329	Johnson	1.223	1.80	49.20	49.00	51.00	44.00	5.00	Dense friable	Lt. buff-grey	.846	Cannel coal, same bed, lower 8 inches.
2332	Knox	1.289	1.80	34.00	64.20	35.80	59.40	4.80	Spongy	Lt. lilac-grey	0.981	Fm G. N. Wiggin's bk, 3 m. s.e. Barboursv'e.
2333	Knox	1.332	1.60	33.80	64.60	35.40	57.14	7.46	Light spongy	Lt. lilac-grey	1.110	Head of Bean's br., n'r m'th of Greasy ck.
2334	Knox	1.281	1.66	36.34	62.00	38.00	58.04	3.96	Light spongy	Nearly white	.651	From same bed; lower 35 inches.
2335	Knox	1.300	2.00	35.00	63.00	37.00	56.70	6.30	Light spongy	Lilac grey	1.091	Head of Sandy Br., 1 m. from Flat Lick.
2336	Laurel	1.221	2.00	35.30	62.10	37.90	60.30	1.80	Light spongy	Nearly white	1.000	On Wood's creek, near John Pitman's.
2337	Laurel	1.496	1.30	31.00	67.70	32.30	43.96	23.74	Dense friable	D'k purpl'h-grey	4.500	"Cannel coal," or bit. shale, W. H. Hayden's, 1½ m. s.w. of London.
2338	Laurel	1.245	3.30	34.44	62.26	37.74	60.96	1.30	Light spongy	Brownish grey	1.055	Head of Raccoon cr., 1 m. from E. Bernstadt.
2339	Laurel	1.277	2.80	35.30	61.90	38.10	59.10	2.80	Spongy	Lt. lilac-grey	.650	Coal No. 1, Pitman Station.
2340	Laurel	1.266	2.72	35.32	61.96	38.04	58.60	3.36	Spongy	Nearly white	0.79	Coal No. 1, Pitman Station, upper part.
a2341	Laurel	n. e.	2.60	29.46	67.94	32.06	52.54	15.40	Spongy	Brownish grey	1.241	Slack coal, Pitman Station; unwashed.
b2341	Laurel	n. e.	2.64	34.00	63.36	36.64	58.70	4.66	Spongy	Lt. lilac-grey	.825	Slack coal, Pitman Station; washed.
2345	Lawrence	1.295	3.20	37.74	59.06	40.94	55.06	4.00	Light spongy	Light grey	.720	Peach Or. c'l, Miller's br.; ent. No. 2, up. b.
2346	Lawrence	1.325	3.30	22.70	74.00	26.00	64.46	9.54	Dense	Lilac grey	1.132	Peach Orchard coal, middle bench.
2347	Lawrence	1.297	3.90	36.80	59.30	40.70	56.30	3.00	Spongy	Nearly white	.756	Peach Orchard coal, lower bench.
2348	Lawrence	1.490	2.20	28.60	69.20	30.80	46.60	22.60	Friable	Nearly white	.550	Peach Orchard bone coal of lower bench.
2349	Lawrence	1.333	4.14	33.06	62.80	37.20	54.50	8.30	Light spongy	Purplish grey	1.722	Headley's coal, head of McHenry branch.
2350	Lawrence	n. e.	4.50	33.70	61.80	38.20	54.38	7.42	Light spongy	Brownish grey	1.708	From same bed, etc.
2352	Letcher	1.291	3.26	32.24	64.50	35.50	61.60	2.90	Dense	Light buff	.656	Holcomb's c'l, h'd Big Laurel br. (outcrop).
2353	Letcher	1.292	1.10	34.80	64.00	35.40	58.10	6.50	Spongy	Light buff-grey	.890	Field's c'l, King's cr.; av. sample of face.

TABLE II.—COALS. (AIR-DRIED.)—CONTINUED.

Number	County.	Specific gravity	Hygroscopic moisture	Volatile combustible matter	Coke.	Total volatile matter	Fixed carbon in the coke	Ash.	Character of the coke	Color of the ash	Percentage of sulphur	Remarks.
2354	Letcher	1.191	1.10	40.90	58.00	42.00	55.46	2.60	Spongy	Brownish grey	1.453	J. N. Thompson's c'l, Sandy Lick; up. lay'r.
2355	Letcher	1.279	1.84	34.30	64.60	35.40	57.20	7.40	Spongy	Light grey	.389	J. N. Thompson's c'l, Sandy L'k, lower lay'r.
2356	Letcher	1.286	1.46	33.26	64.90	35.10	59.70	5.20	Dense	Light buff-grey	.678	McNickel's coal, below Whitesburg.
2357	Letcher	1.242	1.30	35.84	62.70	37.30	58.60	4.10	Light spongy	Brownish-grey	1.068	J. M. Collins' coal, Rockhouse creek.
2358	Letcher	1.277	1.30	39.60	59.10	40.90	55.20	3.90	Light spongy	Brownish	2.812	Caudell's coal; upper layer.
2359	Letcher	1.286	1.60	36.40	62.00	38.00	56.60	5.40	Light spongy	Brownish-grey	1.060	Caudell's coal; lower layer.
2360	Letcher	1.355	8.00	30.06	61.94	38.06	57.60	4.34	Pulverulent	Light buff	.494	From Laurel br. of Ky. river; upper 2 feet.
2361	Letcher	1.319	2.86	31.54	65.60	34.40	62.10	3.50	Dense	Light buff	.535	From Laurel br. of Ky. river; lower 68 ins.
2362	Letcher	1.320	1.34	34.16	64.50	35.50	56.70	7.80	Spongy	Chocolate-grey	1.318	From Cowan's ridge.
2363	Letcher	1.317	1.26	40.30	58.44	41.56	52.70	5.74	Dense	Grey-purplish	2.752	From Camp br. of Rockhouse cr.; lower 45 in.
2364	Letcher	1.305	1.90	39.32	58.78	41.22	51.88	6.90	Dense	Purplish-grey	1.115	From J. Q. Bentley's farm on Rockhouse cr.
2365	Letcher	1.373	7.70	35.50	56.80	43.20	51.96	4.84	Pulverulent	Lt. grey-brown	.832	On Sam Kiser's place, Love br. Rockhouse c.
2366	Letcher	1.483	6.66	31.00	62.34	37.66	46.94	15.40	Pulverulent	Purplish-grey	.488	On Sam Kiser's place, Love br. Rockhouse c.
2367	Letcher	1.385	5.46	31.68	62.80	37.14	57.46	5.40	Pulverulent	Lt. Purpl'h-grey	.488	F'm J. Amberger's farm, Wolf-pen cr., up. prt
2368	Letcher	n. e.	.26	47.94	51.80	48.20	44.86	6.94	Dense	Buff grey	.751	F'm J. Amberger's farm, lower prt cannel bd.
2369	Letcher	n. e.	1.30	38.10	60.60	39.40	58.40	2.20	Light spongy	Purplish-grey	.710	On M. Hale's farm, Trace br., up'r p't can. c.
2372	Magoffin	1.303	2.16	36.98	60.86	39.14	53.86	7.00	Light spongy	Nearly white	.535	F'm Stone's br. on Oakley cr.; lower 20 ins.
2373	Magoffin	1.482	6.92	29.28	63.80	36.20	46.80	17.00	Pulverulent	Light-grey	.541	F'm Stone's br. on Oakley cr.; upper 15 ins.
2374	Martin	1.291	2.60	35.50	61.90	38.10	56.86	5.04	Spongy	Nearly white	.608	G. W. Woods' coal; upper 2 feet.
2375	Martin	1.341	3.54	31.36	65.10	34.90	56.30	8.80	Dense	Light-lilac-grey	.565	From Scaffold Lick br. Rockcastle cr. 6 ft bd.
2376	Martin	1.342	2.20	33.10	64.70	35.30	55.10	9.60	Spongy	Light grey	.578	Coal No. 2, on Beech fork of Rockcastle cr.
2380	Morgan	1.332	1.60	44.00	54.40	45.60	38.86	15.54	Dense	Buff grey	.961	Can. c. Williams' b'k, Rush br. Elk f. Lkg r.
2381	Morgan	1.348	4.26	42.48	53.26	46.74	33.76	19.50	Pulverulent	Fawn colored	1.535	Cannel coal; 42" head n. fork of Licking r.
2382	Morgan	1.373	3.90	39.30	56.80	43.20	38.80	18.00	Friable	Grey-brown	1.106	Cannel coal; 36" Left br. of Mordecai cr.
2383	Morgan	1.308	2.02	41.98	56.00	44.00	44.06	11.94	Dense	D'k purpl'h grey	.810	Cannel coal; 36" sample from upper 30".
2384	Morgan	1.294	2.20	40.50	57.30	42.70	50.30	7.00	Dense	Nearly white	0.805	Can'l c'l, Prater's, Stone Coal br. of Caney cr.
2385	Morgan	1.358	2.90	39.10	58.00	42.00	51.34	6.66	Dense spongy	Dark lilac-grey	4.527	Coal No. 1; 30"; on a fork of Smith's cr.
2392	Muhlenberg	1.268	6.46	34.04	59.50	40.50	55.50	4.00	Spongy	Light lilac-grey	.802	From Mud River mines; middle and bottom.
2397	Perry	1.272	1.50	36.10	62.40	37.60	59.06	3.34	Spongy	Light grey	.618	F'm J. H. Comb's b'k, below and op Hazard.
2398	Perry	1.305	1.30	34.70	64.00	36.00	56.10	7.90	Spongy	Buff grey	.437	F'm mouth Sassafras cr., av. near outcrop.
2399	Pike	1.282	2.60	34.20	63.20	36.80	60.80	2.40	Dense	Light buff	.412	On Big Elkhorn, av. of 7 feet bed.
2400	Pike	1.307	2.60	33.40	64.00	36.00	61.30	2.70	Dense	Light buff	.467	Issac Patton's new bed, head of Elkhorn cr.
2401	Pike	1.271	2.00	33.50	64.50	35.50	60.56	3.96	Light spongy	Light grey	.429	On Big Elkhorn cr., Mullen's br. n'rly 4 ft.
2402	Pike	1.278	1.60	32.10	66.30	33.70	64.64	1.66	Very l't spongy	Lt. redish bro'n	.711	Elkhorn coking coal, Rice's Mill br. of Elkhorn r, lower 45 inches.
2403	Pike	1.271	1.60	29.36	69.04	30.96	67.40	1.64	Inflated	Lt. redish bro'n	.610	Same bed; upper part.
2404	Pike	n. e.	1.80	28.80	71.40	28.60	67.60	3.80	Dense spongy	Brownish red	.967	Slack c'l f'm which coke No. 2413 was made.
2405	Pike	1.355	6.00	31.26	62.74	27.26	59.34	8.40	Pulverulent	Lt. fawn color'd	.390	From Cane br. Elkhorn cr., upper 5' 5½".
2406	Pike	1.314	2.54	32.26	65.20	34.80	62.20	3.00	Dense, hard	Lt. purpl'h buff	.547	From same bed, lower 3' 7".
a2406	Pike	n. e.	n. e.	...	...	...	...	4.40	Dense friable	...	...	"Bone coal," from lower layer of same bed.
2407	Pike	1.279	2.20	36.10	61.70	38.30	58.10	3.60	Spongy	Light buff-grey	.651	From Stone Coal cr., av. of upper 2' 8".

TABLE II.—COALS. (AIR-DRIED.)—CONTINUED.

Number	County.	Specific gravity	Hygroscopic moisture	Volatile combustible matter	Coke.	Total volatile matter	Fixed carbon in the coke	Ash.	Character of the coke	Color of the ash	Percentage of sulphur	Remarks.
2408	Pike	1.293	2.40	35.40	62.20	37.80	58.26	3.94	Spongy	Light buff-grey	.692	From same bed, av. of lower 3 feet.
2409	Pike	1.273	1.40	33.66	64.94	35.06	58.60	6.34	Spongy	Light greyish	.825	Head of Chloe cr., av. of lower 4′ 8″.
2410	Pike	1.367	5.06	29.84	65.10	34.90	57.50	7.60	Pulverulent	Nearly white	1.038	F'm ¾ m. above Pikeville, av. Sycke's b'k.
2417	Pulaski	1.309	3.03	35.01	61.93	38.07	55.98	5.95	Spongy	Grey	1.236	F'm Childer's open'g, br. near h'd Ind'n cr.
2418	Pulaski	1.354	2.68	35.44	61.88	38.12	55.18	6.70	Spongy	Light lilac-grey	2.334	42 inch coal, 3½ miles from Flat Rock sta'n.
2419	Pulaski	1.294	1.67	45.46	52.87	47.13	46.07	6.80	Dense spongy.	Lt. Br'n'h yel.	3.035	Bird's eye cannel coal, near head Barren br.
2420	Pulaski	1.233	2.20	36.24	61.56	38.44	56.96	4.60	Light spongy.	Light buff-grey	.742	From Big View Coal Company's mine.
2421	Pulaski	1.312	1.54	33.80	64.66	35.34	58.26	6.40	Light spongy.	Light grey	1.540	F'm Barren Fork C'l Co., nr. Flat Rock St'n
2422	Pulaski	1.315	1.73	36.24	62.00	38.00	55.26	6.74	Spongy	Light grey	1.296	From "Flat Rock" mines.
2423	Pulaski	1.315	2.50	36.20	61.30	38.70	52.10	9.20	Spongy	Light lilac-grey	2.601	F'm Cumberland C'l Co. (c'l No. 1), Greenw'd.
2424	Pulaski	1.425	2.14	31.46	66.40	33.60	47.74	18.66	Dense	Light lilac-grey	2.140	F'm Beaver Cr. C'l Co. entry No. 1, low'r 12″
2425	Pulaski	1.372	2.06	34.01	63.90	36.10	52.50	11.40	Dense spongy.	Dark lilac-grey	4.250	F'm same bed, en'y No. 2, (conglomerate) 40′.
2426	Pulaski	1.314	2.20	36.56	61.24	38.76	53.14	8.10	Light spongy.	Lilac gray	3.645	From same bed, entry No. 4, middle 31″.
2427	Pulaski	1.323	2.34	34.32	63.34	36.66	56.14	7.20	Spongy	Light buff-grey	1.295	From same bed, entry No. 6, lower 17″.
2441	Whitley	1.275	2.08	35.58	62.34	37.66	58.90	3.44	Spongy	Lt. yell'sh-grey	.567	G. R. Ryan's, Marsh creek, av. of 36″ bed.
2442	Whitley	1.295	1.40	36.74	61.86	38.14	54.20	7.66	Light spongy	Brownish-grey	1.201	F'm Bryvan's op'g, Worley br. up. p't (cong.)
2443	Whitley	1.306	.94	39.86	59.20	40.80	47.30	11.90	Spongy	Lt. grey-brown	3.741	F'm Devil's Jump op'ng, S. F'k Cumberl'd.
2444	Whitley	1.368	1.34	33.06	65.60	34.40	53.88	11.72	Dense spongy	Nearly white	.555	From Bryvan's opening, lower part.
2445	Whitley	1.321	1.50	39.40	59.10	40.90	53.70	5.40	Spongy	Brownish-grey	1.089	From Bryvan's Coal Company.
2446	Whitley	1.254	2.00	34.54	63.46	36.54	61.92	1.54	Spongy	Lt. fawn-colored	.890	F'm G. S. Berry's, 5 m n. of W'l'msb'g, low pt.
2447	Whitley	1.289	2.00	33.40	64.60	35.40	61.90	2.70	Light spongy	Light buff	.637	From same locality, upper part.
2452	State of Ala.	1.259	1.30	37.10	61.60	38.40	54.56	7.14	Light spongy	Grey-buff	1.425	Gaines' bed, Wolf creek, Walker county.
2453	State of Ala.	1.307	1.34	29.76	68.90	31.10	58.10	10.80	Light spongy	Light buff	.685	Mt. Carmel bed, Walker county.
2454	State of Ala.	1.351	1.94	30.46	67.60	32.40	55.04	12.56	Dense friable	Very light buff	.473	Townley bed, top of the bed.
2455	State of Tenn.	1.256	2.36	35.44	62.20	37.80	60.60	1.60	Spongy	Salmon colored	1.162	Jellico Mt. C'l Co., Emmett, Campb. Co., l. layr
2456	State of Tenn.	1.311	2.10	30.84	67.06	32.94	61.56	5.50	Dense	Brownish-grey	2.285	Same company, mine on Crooked creek.
2457	State of Tenn.	1.289	2.90	33.80	63.30	36.70	61.80	1.50	Dense spongy	Lt. yell'sh-bro'n	.670	Same locality.
*	State of Pa.	n. e.	.....	31.36	68.00	.....	59.62	8.23	.....	.....	.784	Connellsville coking coal, Pittsburg seam.
*	State of Pa.	.....	.....	22.38	76.00	.....	68 50	8.00	.....	.....	1.120	Bennington coking coal.
*	State of Pa	.....	.....	16.00	81.00	.....	74.65	7.50	.....	.....	1.850	Broad Top coking coal. (*b*)
*	State of Pa.	.....	.....	19.68	78.00	.....	71.12	7.50	.....	.....	1.700	Broad Top coking coal. (*c*)
2288	W. Virginia	1.185	0.60	42.50	56.90	43.10	49.50	7.40	Dense hard	Grey	1.162	Cannelton cannel coal.

* Quoted from the "Coke Report," of F. Platt, Second Geological Survey of Pennsylvania, Special Report L, 1875. Page 120.

TABLE III. COKES. (AIR-DRIED.)

Number	County.	Moisture expelled below 250° F.	Moisture expelled at red heat.	Fixed carbon	Ash	Sulphur	Color of the Ash.	Remarks.
2289	Bell	0.06	0.60	93.34	6.00	1.335	Dark purplish brown	Made of the coal of Fred. Barner's bank, Yellow creek.
2303	Floyd	....	5.00	88.50	6.50	.788	Reddish grey	Made of the Laynesville coal, No. 1, No. 299.
2325	Hopkins	....	0.86	86.34	12.80	2.233	Purplish grey	From St. Bernard Coal Co.'s mines, of washed slack coal.
2326	Hopkins	....	2.00	77.20	20.80	3.799	Purplish grey	From St. Bernard Coal Co.'s mines, of the unwashed slack coal.
2342	Laurel	....	1.20	95.70	3.10	.659	Light brownish	Of coal No. 1, average of bed, Putnam Station, Laurel Coal Co.
2343	Laurel	....	.90	92.60	6.50	.739	Light brownish	Of the slack coal, same mines.
2344	Laurel	....	2.40	89.20	8.40	.939	Brownish grey	Of the Peacock coal, same mines.
2351	Lawrence	5.10	.90	90.06	3.94	.824	Brownish grey	Of Peach Orchard coal, on Williams' branch.
2377	Martin	.80	....	92.20	9.00	.582	Reddish brown	Coke of coal No. 2376, made in an open fire.
2411	Pike	....	2.86	88.44	8.70	.844	Lilac grey	Made of Elkhorn coking coal, Rice's opening.
2412	Pike	.20	....	93.20	6.60	.734	Brownish red	Made of Elkhorn coking coal, made in an oven in Cincinnati.
2413	Pike	....	1.20	94.14	4.66	1.484	Brownish red	Made from the Elkhorn slack coal, No. 2404, at Connellsville, Pa.
2414	Pike	....	1.10	95.40	3.50	.517	Dark lilac grey	Made of Elkhorn coal, Wm. Mullin's, upper part of the bed.
2415	Pike	....	1.06	90.40	8.54	.588	Light purplish grey	Made of Elkhorn coal, Wm. Mullin's, from mixed sample of coal.
2448	Whitley	....	2.10	90.46	7.44	.665	Chestnut brown	Made of coal A (sub-conglomerate), mouth of Worley river.
2449	Whitley	....	4.80	92.60	2.60	.665	Light brownish grey	Made of J. Berry's coal, of the entire bed.
2458	State of Tennessee	2.90	1.10	91.80	4.20	1.027	Light yellowish brown	Jellico Mt. Coal and Coke Co.'s coal, upper layer.
2459	State of Tennessee	3.70	1.00	92.60	2.70	.725	Light yellowish brown	Jellico Mt. Coal and Coke Co.'s coal, lower layer.
*	State of Pennsylvania	.03	.46	89.576	9.113	.821	....	Connellsville coke, analyzed by McCreath.

*Second Pennsylvania Geological Survey; Special Report L.

TABLE IV. IRON ORES—CARBONATES. (AIR-DRIED.)

Number	County.	Iron carbonate.	Iron peroxide.	Manganese carbonate	Lime carbonate	Magnesia carbonate	Alumina	Phosphoric acid (P2. O5)	Sulphuric acid (SO 3)	Silica and silicates	Organic matter and moisture.	Percent'ge iron.	Percentage silica	Remarks.
2309	Greenup	81.432	. . . .	a 2.758	4.140	2.187	. . . .	0.207	0.587	7.670	1.019	39.631	5.320	Grey iron ore, near Hunnewell Furnace.
2310	Greenup	59.418	15.382	b 1.380	2.800	2.134	4.580	.690	.486	c 12.890	.240	34.780	12.890	Grey iron ore, near Pennsylvania Furnace.
2311	Greenup	80.433	.829	. . . .	1.790	5.517	3.172	.128	n. e.	1.220	6.911	39.400	1.220	Black band, head of Schultz creek.
2312	Greenup	65.545	. . . .	2.096	1.360	1.316	2.752	.128	n. e.	23.790	3.013	30.900	n. e.	Grey kid'y ore, Hibler's drift, h'd Schultz c'k.
2313	Greenup	57.045	. . . .	n. e.	1.310	1.370	2.901	.179	n. e.	27.860	9.337	27.540	n. e.	Grey iron ore, Hibler's drift, h'd Schultz c'k.
2314	Greenup	n. e.	n. e.	n. e.	n. e.	n. e.	n. e.	1.010	n. e.	n. e.	n. e.	26.580	n. e.	Boyce's limestone ore, 1½ m. bel'w Paintville.
2330	Johnson	27.740	15.159	. . . .	1.780	1.970	8.565	1.205	. . . .	35.780	4.801	26.040	33.480	Carbonate iron ore.

a With alumina. b Brown oxide of manganese. c Equal to 1 per cent. of manganese. d Sulphur. e Silica.

TABLE V. IRON ORES—LIMONITES. (AIR-DRIED.)

Number	County.	Iron peroxide.	Br. oxide manganese	Alumina	Lime carbonate	Magnesia carbonate	Phosphoric acid	Sulphuric acid.	Silica, etc.	Water, loss, etc.	Percent'ge iron.	Remarks.
2316	Greenup	82.260	1.642	2.765	0.490	1.318	0.490	n. e.	50.390	10.636	22.750	From Matthews' drift, Schultz creek.
2317	Greenup	39.290	n. e.	3.960	.320	.439	1.010	n. e.	46.480	8.501	27.500	Greycroft's block ore, head of Schultz creek.
2318	Greenup	51.170	n. e.	4.205	.160	.660	.945	n. e.	32.080	10.780	35.820	Red block ore, Rockhouse br. of Schultz creek.
2319	Greenup	52.500	n. e.	4.018	trace.	.287	1.842	n. e.	30.480	10.873	36.750	Limestone kidney ore, head of dry f. of Schultz creek.
2320	Greenup	n. e.	n. e.	n. e.	n. e.	n. e.	n, e.	n. e.	n. e.	n. e.	36.160	Limestone kidney ore, Rockhouse br. of Schultz creek.
2416	Pike	59.630	n. e.	7.927	n. e.	n. e.	.563	n. e.	n. e.	.560	29.720	On Elkhorn creek, 16 m. from its mouth; in blocks.
2450	Whitley	63.380	n. e.	3.776	— traces —		.946	n. e.	15.280	16.618	44.360	J. S. Berry's, five miles north of Williamsburg.

TABLE VI. LIMESTONES. (AIR-DRIED.)

Number	County.	Lime carbonate	Equal to lime	Magnesia carbonate	Iron carbonate	Alumina and iron oxide	Phosphoric acid (P_2O_5)	Sulphuric acid (SO_3)	Potash	Soda	Manganese carbonate	Siliceous residue	Moisture, etc.	Remarks.
2290	Carter	96.380	53.973	1.135	. . .	0.980	Trace.	n. e.	n. e.	n. e.	0.953	0.380	. . . .	Compact limestone, just above the limestone ore.
2292 } 2293 }	Fayette	. . . .	. . . .	. . . .	. . .	. . . .	5.69 to 11.65	. . . .	. . .	. . .	. . . .	. . . .	. . . .	Phosphate limestone layers (eleven samples).
2305	Franklin	87.780	49.157	2.482	. . .	3.812	2.968	n. e.	n. e.	n. e.	n. e.	1.780	1.178	Phosphatic limestone, Lower Trenton formation.
2378	Mercer	62.860	35.200	30.720	. . .	1.220	Trace.	n. e.	n. e.	n. e.	n. e.	5.000	.130	Chazy limestone, Kentucky river cliffs.
2379	Mercer	83.040	46.500	10.550	. . .	10.550	Trace.	n. e.	n, e.	n. e.	n. e.	5.560	2.30	Chazy limestone, Kentucky river cliffs.
2394	Nelson	81.580	45.685	1.501	. . .	2.978	1.202	n. e.	.423	.248	n. e.	11.920	.948	Ferruginous limest'e, near top of upper Hudson beds.
2395	Nelson	61.240	34.294	8.915	. . .	4.317	.563	n. e.	.443	.254	n. e.	22.520	1.748	Ferruginous limestone.
2437	Shelby	40.780	22.837	24.511	. . .	5.917	.563	.941	n. e.	n. e.	. . . .	25.120	2.168	From Jeptha Knobs, Upper Silurian.
2438	Spencer	87.320	48.899	.787	. . .	2.478	1.842	n. e.	.154	.212	. . . .	1.680	5.527	"Phosphatic limestone," lower part of up. Hud. beds.

TABLE VII.—A. MINERAL WATERS—SULPHUR WATERS—*In 1000 Parts of the Water.*

Number	County.	Hydr. sulphide and carbonic acid gases	Iron carbonate.	Manganese carbonate	Lime carbonate	Magnesia carbonate	Soda carbonate.	Lime sulphate.	Magnesia sulphate	Potash sulphate	Soda sulphate.	Calcium chloride	Magn'm chloride	Potass'm chloride	Sodium chloride	Sodium sulphide	Total saline matter	Remarks.
2262	Anderson.	n. e.	.0046	....	.1827	.1434	...	.0700	...	.0441	...	.0814	.1140	...	4.500	.0410	5.1548	Silica—0.0238; lithia, brom., etc., tr'cs
2274	Boyle...	n. e.	.0097	....	.0314		.5089	...	...	.0164	.1841	...	...	...	.1204	...	.8900	Black sulphur; silica —.0191.
2275	Boyle...	n. e.	.0342	....	.0396	.0216	.0870	...	...	.0066	.0080	...	...	...	.0040	...	.2010	Black sulphur.
2276	Boyle...	n. e.	.0100	....	1.4900	.0230	.2880	.2670	.1600	.1920	...	...	...	.0060	.2470	...	2.6830	Black sulphur; traces lithia and brom.
2397	Ohio ...	n. e.	—small quantities not estim'd—				...	.0988	.1580	.0230	.1850	...	...	...	.2000	...	2.954	Silica—0.0780.

TABLE VII.—B. MINERAL WATERS—CHALYBEATE—*In 1000 Parts of the Water.*

Number	County.	Carbonic acid gas	Iron carbonate.	Manganese carbonate	Lime carbonate.	Magnesia carbonate	Soda carbonate.	Iron sulphate.	Lime sulphate.	Magnesia sulphate	Potash sulphate.	Soda sulphate.	Calcium chloride	Magn'm chloride	Sodium chloride	Potass'm chloride	Total saline matter	Remarks.
2269	Boyle...	n. e.	.0298	...	.2257	.0102	...	...	.0313	...	.0067	.0275	...	.0068	...	...	.3451	Silica—0.0071; sulphuric acid, 0.0082.
2270	Boyle...	n. e.	...	...	...	...	...	.1977	.2917	.2250	.0235	.1521	...	...	...	...	1.0240	Silica—0.0384.
2271	Boyle...	n. e.	.1862	trace.	.0199	.0093	...	...	...	...	.0140	...	...	...	.0042	...	.2384	Silica—0.0012.
2272	Boyle...	n. e.	.1654	trace.	.0307	.0133	...	...	...	...	.0140	...	...	...	.0078	...	.2345	Silica—0.0083.
2397	Boyle...	n. e.	...	...	...	...	...	2.6761	.4994	.1350	n. e.	n. e.	...	...	...	...	10.4850	Alum'nm sulph., —5.3477; sulp. acid—.2871.

TABLE VII.—C. MINERAL WATERS—SALINE—*In 1000 Parts of the Water.*

Number	County.	Lime carbonate	Magnesia carbonate	Soda carbonate.	Iron sulphate.	Lime sulphate.	Magnesia sulphate	Potash sulphate	Soda sulphate.	Alumina sulphate	Calcium chloride	Sodium chloride	Magn'm chloride	Total saline matter	Remarks.
2253	Bell	.0656	traces.	.0316	. . .	.0056	.0240	. . .	. . .	. . .	.0027	. . .	. . .	.1077	Traces of iron and alumina; silica, 0.0076.
2277	Boyle	.0151	.0278	. . .	. . .	.0408	trace.	.0024	.0016	. . .	.0068	. . .	. . .	.1021	Traces of iron carbonate; silica, not estimated.
2278	Boyle	.1980	.0060	.0780	. . .	1.7660	3.1240	.2490	.1320	. . .	. . .	n. d.	. . .	5.6750	Iron carbonate, 0.1020; trace of lithia.
2279	Boyle	.1500	.0170	. . .	. . .	.6010	.9600	.0500	1.021	. . .	. . .	. . .	. . .	3.4180	Iron carbonate, 0.0150; lithia, salt, 0.310.
2280	Boyle	1.4900	.0230	.2980	. . .	.2670	.1600	.1920	. . .	. . .	. . .	.2470	. . .	2.6830	Iron carbonate, 0.0100; potassium, chloride, 0.0060.
a2280	Boyle	1.4540	1.3670	. . .	. . .	.1980	. . .	.1450	. . .	. . .	. . .	13.9790	. . .	19.2000	Traces of lithia and strontia.
b2280	Boyle	.1180	.0140	. . .	. . .	.2400	. 1280	.0220	.1120	. . .	. . .	.0070	. . .	.698	Iron carbonate, 0.035; traces of lithia.
2281	Kenton	.3558	.0052	. . .	. . .	1.0089	1.3511	.0267	.8944	. . .	. . .	.1126	. . .	3.2945	Iron carbonate, a trace; silica, 0.0018.
2270	Logan	.0504	.0084	. . .	.0000	.3134	.0000	.0143	.1066	. . .	. . .	.0000	.0170	.5771	Iron carbonate, 0.0561; silica, 0.100.
2271	Logan	.3485	.0101	. . .	trace.	1.1886	.9873	.0000	.0000	. . .	. . .	.0000	.0000	2.9053	Iron carbonate, 0.2980; traces of lithia.

GEOLOGICAL SURVEY OF KENTUCKY.

JOHN R. PROCTER, DIRECTOR.

CHEMICAL REPORT

OF THE

Soils, Coals, Cokes, Ores, Marls, Clays, Mineral Waters, Etc., Etc.,

OF KENTUCKY.

BY ROBERT PETER, M. D., ETC., ETC.,

CHEMIST TO THE SURVEY,

ASSISTED BY ALFRED M. PETER, S. M.

The sixth Chemical Report in the New Series, and the tenth since the beginning of the Geological Survey.

JOHN D. WOODS, PUBLIC PRINTER AND BINDER. 109

INTRODUCTORY LETTER.

CHEMICAL LABORATORY, KENTUCKY GEOLOGICAL SURVEY,
STATE COLLEGE, LEXINGTON, KY., Sept. 20, 1884.

JOHN R. PROCTER, *Director of Kentucky Geological Survey, etc.:*

DEAR SIR: I have the honor herewith to transmit to you for approval and publication my report of the unpublished chemical work in this Laboratory up to the present date. Very respectfully,

ROBERT PETER.

CHEMICAL REPORT.

Of the sixty-eight chemical analyses reported in the following pages, there are:

25	Soils and subsoils
17	Coals
6	Cokes
8	Clays
3	Marly shales and marls
10	Limestones
6	Mineral waters

The twenty-five soils and subsoils were collected from different geological formations as follows:

One from Clark county; an exceptional soil because of its swampy character; a "crawfish" soil, resting on the middle Hudson or mudstone formation.

Ten soils and subsoils, from Madison county; collected from middle and upper Hudson, black shale and Waverley formations severally.

Eight soils and subsoils from Montgomery county; collected from virgin soils and old cultivated fields, for comparison, were from the middle and upper Hudson river beds.

Four soils and subsoils, from Rockcastle county were from the St. Louis limestone and conglomerate formations.

In addition, for comparison with these soils, a soil and subsoil from a sandy region in *Florida is given.*

AVERAGE COMPOSITION OF THESE KENTUCKY SOILS ON THE DIFFERENT GEOLOGICAL FORMATIONS.

Formation.	Organic matters.	Alumina etc.	Iron oxide.	Lime carbonate.	Magnesium.	Phosphoric acid.	Potash ext'd by acids.	Silicious residue.	Hygroscopic moisture	Potash in silic. residue.	Gravel, etc.	Character.
Middle Hudson	3.670	5.832	5.163	0.413	0.440	0.175	0.430	83.056	2.832	1.872	2.778	Av. six soils and subsoils
Upper Hudson	4.910	5.693	4.667	.573	.361	.258	.433	82.003	2.641	1.549	1.514	Av. six soils and subsoils
Black Shale . .	3.776	5.081	4.064	.095	.253	.087	.328	85,327	1.217	2.680	4.285	Av. of soil and subsoil.
Waverley . . .	2.513	5.408	3.950	.079	.383	.035	.467	86.841	1.995	1.732	10.160	Av. of soil and subsoil.
St. L. Limestone	3.821	9.548	4.612	.099	.184	.045	.278	80.489	2.287	.251	3.905	Av. of soil and subsoil.
Conglomerate .	3.104	3.800	1.862	.041	.086	.050	.267	90.484	1.192	.690	2.855	Av. of soil and subsoil.
Recent (Florida)	.813	.410		.083	.057	n. e.	.100	99.021	Not estimated.			Av. of soil and subsoil.

Excluding the exceptional soil from Clark county, which although from an elevated locality on the middle Hudson formation is characterized as being "swampy and poor," owing, mainly, as the analysis shows, to want of drainage and its deficiency in phosphoric acid; excluding also soils Nos. 2488–9 of Madison county from our comparative view of the relative composition of the soils of the different geological formations given in the preceding table, because they also are in a marshy locality, a local glade, and had their original composition modified by the surface wash from the neighboring higher territory, etc., we find in our comparative table marked indications of the influence of the sub-strata upon the soils resting on them, and which most probably have been produced by the disintegration and decomposition of the rocks on which they rest. For instance:

The soils on the upper Hudson—excluding the exceptional Clark county soil—are richer than any of the others,—containing larger proportions of organic and volatile matters, lime, phosphoric acid and potash; and leaving less of silicious residue insoluble in acid and gravel.

Next in fertility come the soils of the middle Hudson and St. Louis Limestone formations, but the latter are quite deficient in phosphoric acid.

The soils of the black shale would come next, and if well-drained, would compete in fertility with the above named soils. The soil and subsoil Nos. 2488 and 2489, excluded from the above comparative table, because they are in a marshy locality, with the exception of a want of lime, have the chemical composition of a rich soil.

The Waverley soils are poorer than these, as shown especially by their very small proportions of phosphoric acid and lime and considerable quantity of gravel; and the Conglomerate formation soils, deficient in phosphoric acid, lime and magnesia, and containing more than ninety per cent. of sand and insoluble silicates, are the poorest of all these Kentucky soils.

But when we look at the composition of the Florida soils, so-called, with their average ninety-nine per cent. of pure silicious sand, and know that they are made profitably fertile in the con-

stant production of tropical fruits and other crops by the regular use of artificial fertilizers, we need not despair of our most sandy and naturally sterile soils.

Many recorded experiments in what is called *water culture;* in which the roots of growing plants are simply immersed in water containing small quantities dissolved of the essential mineral elements of plant food, and in which they grew and formed seed; show that much of the influence of the soil on vegetation is mechanical. The soil sustains the plant in place and offers open and protective space for the development and ramification of its roots and minute rootlets, while it freely admits the access to them of the essential elements of the atmosphere above and the soil water from below. The rich store of mineral food contained in the earthy matter of a fertile soil would be worthless but for these mechanical conditions.

In the loose and porous sandy soil roots of plants take on a much wider development than in heavier soils, and thus range over a greater space in search of nourishment. In these light soils, so-called, the atmospheric agencies have a more free circulation, and the conditions are highly favorable for the production of the nitrogen compounds of plant food, and the subsoil water, held to a certain height in the soil by capillary attraction, may hold and supply to the plant the mineral elements it requires. The plow is not so essential in the light sandy soil for maintaining the porosity necessary to fertility as in the heavier loam soil. But the absence or paucity of alumina, iron oxide, and humus; all of which ingredients possess the valuable property of absorbing, and holding, for the use of growing plants, the essential elements of vegetable food, necessitates a constant and regular feeding of the growing crops by the judicious use of artificial fertilizers. This artificial feeding of the crops being necessarily costly demonstrates the greater value of the naturally rich soil.

In the numerous soil analyses made for the Kentucky Geological Survey the proportion of nitrogen or its compounds in the soil have not been determined; this omission seems to some observers the neglect of an essential element of fertility. But

in declining to ascertain the proportion present of this essential aid to plant growth in the soils he analyzed the writer was mainly influenced by the fact, which was thoroughly established many years ago by the indefatigable and accurate agricultural chemist of France, the celebrated Boussingault, and others, that the nitrogen compounds were very variable in quantity in any given soil; being dependent greatly on the conditions of the weather, etc. For, while they might be abundant in a rich and moderately moist and porous soil during dry weather, a good rainfall would temporarily reduce their proportions in a marked degree in consequence of their ready solubility in water. Moreover, nitrates are produced more rapidly and in greater quantity in warm weather than in cold, and their proportion and quantity, in any given soil, depend greatly on its temporary conditions of lightness or porosity, compactness, moisture, etc., etc.; independent of its composition. The varying conditions of the atmosphere; its relative moisture, temperature, and different electrical states; its proportion of ozone, etc., all affect the nitrogen compounds of the soil.

Of the seventeen COALS analyzed and reported five are *cannel* coals and twelve are semi-cannel, splint or "block" coals. The average composition of these two varieties is given in the following table, excluding the two very impure cannel coals from Lawrence county, which have an average ash percentage of 19.13, and therefore nearly approach the character of bituminous shales:

AVERAGE COMPOSITION.

(*Air-dried*).

	Volatile combustible matters . .	Coke . . .	Ash . . .	Carbon in the coke.	Sulphur .
Of the three cannel coals . . .	49.99	48.58	8.08	40.37	1.518
Of the twelve splint coals . .	33.64	64.29	4.86	59.63	.783

The cannel coals differ from the other varieties of coal in containing a larger quantity of volatile combustible matters in pro-

portion to the coke and fixed carbon, and they frequently contain a larger quantity of ash material. Most of the splint coals analyzed seem to be adapted to the manufacture of coke of a good or superior quality, and some may be employed for the smelting of iron without previous coking.

Owing to their large proportion of volatile combustible matters, the cannel coals yield a large quantity of combustible gas when submitted to destructive distillation. This gas is so rich in carbon from some varieties of this coal that they are profitably used to enrich the gas from poorer coals. Some of these coals yield more of liquid hydro-carbons—tars, coal oils, etc.—than of permanent gas, which is peculiarly the case with the well-known Breckinridge coal of Kentucky. The gas maker, however, generally prefers a soft or bituminous or semi-bituminous coal, which will make good porous coke, because the coke from the cannel coals is dense and not so generally merchantable.

A very large percentage of ash in a cannel coal which contains a great proportion of volatile combustible matters does not always prevent it from being profitably used in the production of gas, provided its impure coke can find a useful or profitable application. According to P. Schutzenberger (*Wurtz's Dictionnaire de Chemie, Art. Houille*), a Scotch cannel coal, of Ridgeside, which contained 52.80 per cent. of volatile combustible matters and 17.60 per cent. of ash, gave more gas than a Newcastle gas coal (English), which gave only 35.63 per cent. of volatile combustible matters and left only 0.97 per cent. of ash. This cannel coal gave 342 liters of very rich gas to the kilogram, while the Newcastle gas coal gave 325 liters of inferior gas to the kilogram.

Of the six cokes analyzed, the proportions of

Carbon varied from	94.80	to 81.10
Ash varied from	3.20	to 17.20
Sulphur varied from	0.835	to 4.85

The best coke was that from Whitley county. The most impure, from Hopkins county, had been made from very impure slack coal, which thus proved to be unfit for the manufacture of

merchantable coke. It has been proved by many trials that some of our Kentucky coals will yield as good coke as can be made in any region.

Of the eight *clays* reported, the four samples from Carter county, from the same locality, are good fire clays. No. 2463 is especially good because of its paucity of the fluxing agencies, iron oxide, lime, magnesia, potash and soda, and compares very favorably with one of the most celebrated fire clays of New Jersey. No. 2464 would no doubt withstand heat nearly as well as this, notwithstanding its greater proportion of iron oxide, as its lime, magnesia, potash and soda are somewhat less. The larger excess of iron peroxide in the other samples causes them to be somewhat less refractory; but probably much of this could be removed or avoided as superficial and local incrustation.

The *plastic clays* of Madison county and indurated bituminous clay of Whitley could be utilized in common pottery, etc. The three *marly* clays and shales give no promise of any great utility. That, however, from Carter county, containing 13.88 per cent. of carbonate of lime, 3.02 of potash and 0.205 of phosphoric acid, might be advantageously applied to light sandy soil deficient in lime, etc., but would not pay for distant carriage.

Most of the ten limestones reported were examined mainly to ascertain their proportion of phosphoric acid, and this valuable ingredient was found to exist in these ten samples in proportions varying from 9.710 per cent. in No. 2469, Oriskany limestone from Clark county, down to 0.143 per cent. in the hydraulic limestone No. 2484, from Lewis county, and a mere trace in the oolitic limestone No. 2460 (*b*). The several samples of the so-called blue limestone, or Trenton limestone, of Fayette county were examined solely with this purpose, and gave from 3.880 to 3.487 per cent. The sample from Franklin of the same geological formation contained 4.029 per cent.

These phosphatic limestones, which underlie and give character to our richest soils, could no doubt be profitably employed in the pulverized state to improve soils which are deficient in phosphoric and lime.

The limestones from Clark county, Nos. 2469 and 2470,

would very probably yield hydraulic cement if properly calcined.

A trial was made in a small way, in the Laboratory, of the limestone from Lewis county, No. 2484, and it was found that after sufficient calcination at a high temperature the powdered rock, mixed to a proper consistence with water without the addition of sand, hardened under water in the course of a day's time, and maintained the hardness of stone, although alternately dried and again immersed in water. Whether it would bear admixture with sand was not tried.

This limestone, as well as No. 2478, from Harlan county, contained soluble silica, and this latter, containing more silica than the Lewis county limestone, would very probably form good water cement if properly calcined. In this relation the two Clark county limestones deserve a trial, although they both contain rather large proportions of silica.

The purest of all these limestones, which would yield the whitest lime, are the oolitic limestone from Caldwell county, No. 2460 (*b*), and that from Lyon county, No. 2485.

A summary of the composition of the six mineral waters analyzed is given below:

	No. 2471	No. 2472	No. 2473	No. 2474	No. 2474 (*bis*)	No, 2521
Hydrogen sulphide gas	0.0000	0.0000	0.0000	0.0000	n. e.	2c.c. to the l'tr
Carbonic acid gas	n. e.	n. e.	n. e.	n. e.	n. e.	n. e.
Iron and manganese carbonates	0.0024	0.0041	0.0192	0.0000	0.006	0.061*
Lime carbonate	.3740	.1198	.0004	.0000	.156	.042*
Magnesia carbonate	.0191	.0185	.0002	.0000	.051	.037*
Potash carbonate	.0000	.0000	. .	.0099	.022	. . . .
Soda carbonate	.0000	.0000	. .	.5266	.033	trace.
Alumina sulphate	.0000	.0000	.0586	.0000	.000	.000
Lime sulphate	8.2610	.0583	.0432	.0265	.038	.144
Magnesia sulphate	4.7776	.0000	.0000	.0000	.000	.000
Potash sulphate	.0490	.0000	.0119	.0000	.000	.000
Soda sulphate	.7118	.0000	.0000	.0000	.000	.000
Sodium sulphide	.0000	.0000	.0000	.0000	.012	.000
Calcium chloride	.0000	.0096	.0000	.0035	.000	. . . .
Magnesium chloride	.0000	.0845	.0024	.0159	.067	. . . .
Sodium chloride	.2120	.0978	.0162	.0371	.000	.020
Potassium chloride	.0000	.0196	.0055	.0000	.000	.015
Lithium chloride	.0130	.0000	trace.	.0000	.000	.000
Silica	.0100	.0158	.0555	.0168	.067	.012
Total saline matters in 1,000 parts of the water,	9.4299	0.4275	0.2131	0.6868	0.452	0.331

*Held in solution by carbonic acid.

Five of these mineral waters are from Clark county, viz.: Nos. 2471, 2472, 2473, 2474 and 2474 (*bis*).

No. 2471 is a pretty strong magnesian saline water, from near Kiddville, resembling the principal Crab Orchard waters.

No. 2472, called Oil Spring water because of some traces of the presence of petroleum in it; which, however, could not be perceived in the sample sent for analysis; is a weak, slightly chalybeate, saline water.

No. 2473 is a weak chalybeate, alum water.

No. 2474, from a so-called "Soda Spring," is an alkaline saline water.

No. 2474 (*bis*), from "Red Sulphur Spring," is a slightly chalybeate and saline sulphur water, containing not only free hydrogen sulphide, but also a small proportion of sodium sulphide. It is also slightly alkaline.

No. 2475 is from the so-called Arcadia Spring, in Warren county. It is a good weak chalybeate and saline sulphur water.

BRECKINRIDGE COUNTY.

No. 2460—MARLY SHALE: "*From Buffalo Licks, a mile and a half below Cloverport. Sample sent by Mr. Robert Bryce.*"

COMPOSITION (*Air-dried*).

Silica	73.500
Alumina and iron oxide	16.760
Lime carbonate	.280
Magnesia carbonate	1.892
Potash	2.085
Soda	.034
Water and loss	5.449
Total	100.000

This shale contains only a trace of phosphoric acid, and its potash is in such firm combination as not to be immediately available for plant nourishment; so that it does not promise much as a fertilizing agent when applied to the soil.

BUTLER COUNTY.

No. 2460 (*a*)—COAL: "*From a bed, four feet thick at Mining City, Butler county, on Green river. Sample sent by E. B.*

Seeley, Secretary and Treasurer of the Green and Barren Rivers Navigation Company, September 20, 1884."

A bright, pure-looking coal, breaking readily, with an irregular shining fracture, showing imperfectly so-called bird's-eye structure in some parts. Has very little fibrous coal, in patches, and no apparent pyrites. Softens and swells somewhat on burning. Seems to approach in character to soft or bituminous coal.

COMPOSITION (*Air-dried*).

Specific gravity			1.221
Hygroscopic moisture	8.00	Total volatile matters	42.36
Volatile combustible matters	34.36		
Spongy coke	57.64	Carbon in the coke	54.24
		Very light buff-grey ash	3.40
Total	100.00	Total	100.00
Percentage of sulphur			0.876

This is a very good coal, containing but a small proportion of ash, and not more than an average quantity of sulphur. It would probably make good coke.

CALDWELL COUNTY.

No. 2460 (*b*)—OOLITIC LIMESTONE: "*Ten to twelve feet thick; from McElpatrick's Quarry, four miles east of Princeton, Caldwell county. Collected by R. H. Loughridge, November 1884.*"

A light-buff-grey oolitic limestone, containing occasional small crystals of calc. spar and minute cavities stained with hydrated ferric oxide. Scarcely adheres to the tongue, but absorbs some water.

COMPOSITION (*Air-dried*).

Lime carbonate	97.64=54.678 per cent. of lime.
Magnesia carbonate	1.18
Iron peroxide and trace of phosphoric acid	.28
Silicious residue	1.16
Total	100.26

A remarkably pure limestone, which would calcine into very white and pure quicklime.

CARTER COUNTY.

No. 2401—MARL: "*From the mines of the Carter County Lime-*

stone Mining Company. Found in their quarry in a bed about three feet thick. (Supposed to be useful as a fertilizer.)"

A compact marl, of chocolate and dirty green colors. Adheres to the tongue. Soft enough to be scratched by the nail.

COMPOSITION (*Air-dried*).

Silica	58.440
Alumina	13.375
Iron oxide	5.000
Lime carbonate	13.880
Magnesia carbonate	8.420
Phosphoric acid (P_2O_5)	.205
Potash	3.020
Soda	.282
Moisture and loss	2.378
Total	100.000

As this contains a considerable percentage of carbonates of lime and magnesia, as well as a fair proportion of phosphoric acid and three per cent. of potash, which, however, would not be immediately available as a fertilizer, this marl may be found beneficial on poor, sandy soil in its immediate vicinity, where the cost of transportation would not preclude its use.

The sample of this marl was accompanied by two lumps of nearly white LIMESTONE from the quarry in which the MARL bed is found. This limestone is a compact, light-cream-colored rock, containing specks of small crystals of calc. spar. On testing, it was found to be nearly pure carbonate of lime, containing only a trace of phosphoric acid. The proprietors are said to be crushing this limestone for use as a fertilizer. Its principal valuable ingredient is its carbonate of lime; it is therefore not better as a fertilizer than any ordinary limestone.

No. 2462—CANNEL COAL: *"From Hyston's branch of Little Fork of Little Sandy river, four miles south of E. K. R. R., at Willard, Carter county. Average thickness of the bed two feet, with fifteen inches of semi-cannel coal on top. Owned by Wm. Mitchell, of Mt. Sterling. Sample sent by Capt. J. M. Bent, of that place."*

A firm, tough, dull-black coal. Fracture broad, irregular

conchoidal. A small quantity of bright granular pyrites in a narrow, irregular vein. No fibrous coal apparent.

COMPOSITION (*Air-dried*).

Specific gravity			1.256
Hygroscopic moisture	0.90	Total volatile matters	57.40
Volatile combustible matters	56.50		
Coke (dense, friable)	42.60	Carbon in the coke	35.06
		Brownish-grey ash	7.54
Total	100.00	Total	100.00

Its percentage of sulphur is 2.200.

A pretty good cannel coal. Its percentage of ash is large, but not excessive.

Clays from Carter County.

No. 2463—FIRE CLAY (SAMPLE No. 1): "*From Perry's branch of Tygart's creek, near its mouth, and near the E. L. & B. S. R. R. Thickness of bed, three to nine feet. Owned by the Tygart Valley Iron Company. Sample sent by K. B. Grahn, Secretary and Treasurer of the company, Olive Hill, Carter County.*"

A very light grey, nearly white, compact, indurated clay. Breaks easily, with irregular, broad conchoidal fracture. Adheres slightly to the tongue. Imperfectly oolitic, with small spheroidal concretions of the size of mustard seed. Before the blowpipe it calcines white and is quite refractory, softening very little in the greatest heat.

No. 2464—FIRE CLAY (SAMPLE No. 2): "*From the same locality as the preceding, etc., etc.*"

A compact, indurated clay, of a yellowish light-grey tint; more firm than the preceding clay. Does not adhere to the tongue. Is a little more oolitic than that. The exterior surfaces are strongly colored with iron peroxide. Before the blowpipe it calcines nearly white, with a slight tint of reddish. Is refractory, but softens a little in the intense heat.

No. 2465—FIRE CLAY (SAMPLE No. 3): "*From the same locality as the preceding, etc., etc.*"

Resembles the next preceding in firmness, fracture and oolitic character. Does not adhere to the tongue. Calcines, before the blowpipe, of a light brick-reddish color. Is refractory, but softens a little more than the preceding in the intense heat.

No. 2466—FIRE CLAY (SAMPLE No. 4): "*From the same locality as the preceding, etc., etc*"

Resembles the preceding, but is rather more oolitic. Is of a brown-grey color, with a thin, irregular vein of greenish-grey. Hardly adheres to the tongue. Before the blowpipe it calcines of a light brick-reddish tint. Is refractory, but softens a little more than the next preceding. For comparison the analysis of the celebrated "Woodbridge Fire Clay" of New Jersey is given in the following table.

COMPOSITION OF THESE CARTER COUNTY FIRE CLAYS, ETC.
(*Air-dried.*)

	No. 2463	No. 2464	No. 2465	No. 2466	No. 2467*
Silica	43.58	44.84	41.28	41.58	39.760
Alumina	40.86	40.18	40.56	38.38	42.850
Iron peroxide	.76	1.76	4.42	4.04	.940
Lime	.29	.21	.60	.21	.398
Magnesia	.14	.13	.17	.10	.650
Potash	.19	.17	.11	trace.	.477
Soda	.05	.06	trace.	trace.	. .
Water and loss	14.43	12.65	12.86	15.69	14.640
Total,	100.00	100.00	100.00	100.00	99.715

*Woodbridge fire clay of New Jersey, copied from the second Report of the Geological Survey of New Jersey, for 1855, page 100.

This Woodbridge fire clay is said (in this Report) to be of the "best fire clay," and that it will "stand an intense heat better than the imported brick." The best sample of the Carter county clay, No. 2463, contains less of the ordinary fluxing materials of clays, viz.: iron oxide, lime, magnesia, potash and soda, and the other samples exceed it only in iron oxide, much of which—it being mainly an exterior coating—could probably be excluded in mining or removed by scraping.

CLARK COUNTY.

No. 2468—VIRGIN SOIL: "*From a level tract of land on the farm of W. H. Prewitt, on the divide between Hinkson and Lulbe-*

grud creeks. Here there is about thirty acres of white crawfish land on a high point of the county. It is swampy and poor. (Would drainage or fertilizers help it?) On middle Hudson beds and silicious mudstone. Collected by W. M. Linney, May 15, 1884."

The dried soil is of a light grey-buff color; it is in friable clods. The coarse seive* removed from it 10.3 per cent. of ferruginous concretions, etc. Its silicious residue, from digestion in acids, all passed through the fine seive† except a small quantity of fine hyaline quartz grains.

COMPOSITION (*Dried at 212° F.*)

Organic and volatile matters		3.102
Alumina and manganese oxide		4.067
Iron oxide		2.140
Lime carbonate		.250
Magnesia		.169
Phosphoric acid (P_2O_5)		.080
Potash extracted by acids		.127
Soda extracted by acids		trace.
Water expelled at 360° F.		.598
Sand and insoluble silicates		88.946
Total		99.479
Hygroscopic moisture	2.025	
Potash in the insoluble silicates	.807	
Soda in the insoluble silicates	.434	

The most evident deficiency in the composition of this soil is of phosphoric acid. It would, therefore, undoubtedly be benefited by top dressings of bone dust, super-phosphates or guanos. But as the land is said to be swampy, drainage also should be employed.

Limestones of Clark County.

No. 2469—PHOSPHATIC LIMESTONE: "*Stewart's Mill, Lulbegrud creek, Clark county. Oriskany formation. Collected by W. M. Linney, July, 1884.*"

A dark, brown-grey, conglomerate rock, containing many dark colored fragments of fossil organic remains.

* With 64 meshes to the centimeter square.

† With 1600 meshes to the centimeter square.

No. 2470—PHOSPHATIC LIMESTONE: "*From near Howard's creek, Clark county. Oriskany formation? Collected by W. M. Linney, July, 1884.*"

An impure, ferruginous limestone rock; grey-brown, with ochreous material in spots; contains fossil impressions.

COMPOSITION OF THESE CLARK COUNTY LIMESTONES.

(*Air-dried*).

	No. 2469	No. 2470
Lime carbonate	21.880	33.980
Magnesia carbonate	3.055	11.185
Alumina and iron oxide	n. e.	n. e.
Phosphoric acid (P_2O_5)	9.710	1.842
Potash	.830	n. e.
Soda	.228	n. e.
Silicious residue insoluble in acids	27.580	31.720

As the analysis of these samples of rock was mainly for the determination of the phosphoric acid they contained, it was not fully carried out as to other constituents of these rocks. It shows, however, that No. 2469 might be available, if crushed to powder, as a top-dressing to soils deficient in phosphoric acid and lime. It is quite probable, also, from its composition, that No. 2470 might be employed in the manufacture of hydraulic cement. This, however, can only be ascertained by skillful, practical trials.

Mineral Waters of Clark County.

No. 2471—MAGNESIAN MINERAL WATER: "*At Kiddville, on the property of J. E. Groves. Collected by W. M. Linney, July, 1884.*"

Reaction of the water neutral. It tastes stongly of epsom salt.

COMPOSITION, *in 1000 Parts of the Water.*

Iron and manganese carbonates	0.0024	Held in solution by carbonic acid.
Lime carbonate	.3740	
Magnesia carbonate	.0191	
Lime sulphate	3.2610	
Magnesia sulphate	4.7776	
Potash sulphate	.0490	
Soda sulphate	7.118	
Sodium chloride	.2120	
Lithium chloride	.0130	
Silica	.0100	
Total saline matters	9.4299	in 1000 parts.

This water resembles the waters of the Crab Orchard Springs, of Lincoln county, from which the so-called "Crab Orchard salts" are prepared by evaporation. It contains, however, a larger proportion of sulphate of lime than those waters generally, and more of magnesia sulphate (epsom salt) in proportion to the sodium chloride (common salt).

No. 2472—MINERAL WATER: "*From 'Oil Spring,' near Lulbegrud creek, Clark county. Property of A. M. Eastin. Issues from near the junction of the corniferous and black slate formations. Collected by W. M. Linney, August 3, 1884.*"

The water is said to have petroleum in it, but none could be observed in the sample.

COMPOSITION, *in 1000 Parts of the Water.*

Iron carbonate	0.0041	Held in solution by carbonic acid.
Lime carbonate	.1198	
Magnesia carbonate	.0185	
Lime sulphate	.0583	
Calcium chloride	.0096	
Magnesium chloride	.0845	
Sodium chloride	.0973	
Potassium chloride	.0196	
Silica	.0158	
Total saline matters	0.4275	

A weak saline water, very slightly chalybeate.

No. 2473—MINERAL WATER: "*From the chalybeate spring at Stuart's Mill, owned by Stuart & Harmer, near Lulbegrud creek, Clark county. Flows from Oriskany sandstone. Collected by W. M. Linney, August 3, 1884.*"

COMPOSITION, *in 1000 Parts of the Water.*

Iron carbonate	0.0192
Lime carbonate	.0004
Magnesia carbonate	.0002
Lime sulphate	.0432
Alumina sulphate	.0586
Potash sulphate	.0119
Magnesium chloride	.0024
Potassium chloride	.0055
Sodium chloride	.0162
Lithium chloride	traces, not est.
Silica	.0555
Total saline matters	0.2181

This is a chalybeate, alum water.

No. 2474—MINERAL WATER: "*From the 'Soda Spring,' at Stuart's Mill, Lulbegrud creek, Clark county. Collected by W. M. Linney, August 3, 1884.*"

COMPOSITION, *in 1000 Parts of the Water.*

Lime sulphate	0.0265
Calcium chloride	.0035
Magnesium chloride	.0159
Sodium chloride	.0371
Soda carbonate	.5266
Potash carbonate	.0099
Silica	.0168
Total saline matters	0.6363

An alkaline saline water. In the recent water the alkalies are in the form of bi-carbonates.

No. 2474 (*bis*)—RED SULPHUR WATER: "*From the farm of C. C. Eastin, near Lulbegrud, Clark county. Flows from black slate. Collected by W. M. Linney, August 3, 1884.*"

COMPOSITION, *in 1000 Parts of the Water.*

Hydrogen sulphide gas	*	
Carbonic acid gas	not estimated.	
Iron carbonate	0.006	Held in solution by carbonic acid.
Lime carbonate	.156	
Magnesia carbonate	.051	
Magnesium chloride	.067	
Lime sulphate	.038	
Sodium carbonate	.038	
Potassium carbonnte	.022	
Sodium sulphide	.012	
Silica	.067	
Total saline matters	0.452 in 1000 parts of the water.	

* Not quite two centimeters to the liter in the water brought to the laboratory.

A good weak sulphur water, slightly alkaline and chalybeate.

FAYETTE COUNTY.

No. 2475 (*b*)—PHOSPHATIC LIMESTONE: "*From a quarry on the farm of Mr. Christopher Keiser, six miles from Lexington, on the Newtown turnpike.*"

A portion of a thin layer, weathered brownish-buff on the exterior surface, the interior being of a bluish-grey color. Granular crystalline, containing some minute fossil remains. Trenton limestone or blue limestone formation. Analyzed by Mr. J. H. Kastle. This gave 3.88 per cent. of phosphoric acid (P_2O_5).

No. 2475 (*c*)—PHOSPHATIC LIMESTONE: "*From a quarry on the hillside, just beyond the first tollgate from Lexington, on the Newton turnpike.*"

Sample (*a*), the brownish, coarse-granular, crystalline portion, containing fragments of fossil shells, gave 2.56 per cent. of phosphoric acid (P_2O_5). Sample (*b*), the fine-grained, bluish-grey, varied with lighter colored, more laminated portion, with no apparent fossil remains, gave 3.487 per cent. of phosphoric acid (P_2O_5). These two samples were also analyzed by Mr. Kastle.

In the preceding chemical reports several other analyses are given of this phosphatic limestone, which underlies the well-known rich Bluegrass region, in some of which much larger proportions of phosphoric acid are shown. While this valuable and essential ingredient of fertile soil appears to be present in all the beds of this limestone, the richest layers, which have heretofore been examined, are only occasionally found, in irregular and limited quantity.

FRANKLIN COUNTY.

No. 2476—PHOSPHATIC LIMESTONE: "*From the Trenton limestone formation. Taken from the railroad cut two miles above Frankfort. Collected by W. A. Linney, February 10, 1884.*"

A grey rock, brownish-grey on the weathered surfaces, spark-

ling with minute, irregular crystals, and containing small fragments of fossil shells. By the molybdic process this gave 4.029 per cent. of phosphoric acid (P_2O_5).

FLOYD COUNTY.

No. 2477—COKE: "*From coal of Judge Layne's coal bed, half way between Prestonsburg and Pikeville, Floyd county. Coked by R. C. Ballard, January 29, 1884. (42 hours.)*

A bright, firm, irregularly columnar coke. (Some pieces of shale in the sample.)

COMPOSITION (*Air-dried*).

Moisture and volatile matters	0.60.
Carbon in the coke	94.70
Reddish-brown ash	4.70
Total	100.00

Its percentage of sulphur is 0.885.

Quite a good, pure coke.

HARLAN COUNTY.

No. 2478—BITUMINOUS LIMESTONE: "*From Poor Fork of Cumberland river, half a mile from Creech Post-office. Geological position, near the line between the lower coal measures and the unproductive. Collected by R. C. Ballard, December, 1883.*"

A dull, fine-grained, grey-black limestone, containing whitish fragments of fossil shells.

COMPOSITION (*Air-dried*).

Lime carbonate	59.00
Magnesia carbonate	1.82
Alumina, iron oxide, etc.	4.80
Soluble silica	1.38
Insoluble silica and silicates	16.36
Bituminous matter, moisture, etc.	16.64
Total	100.00

Alkalies, etc., not determined.

It is probable that this limestone may give hydraulic cement, if properly calcined.

Coals of Harlan County.

No. 2478 (*a*)—COAL: "*From thirty miles above Mt. Pleasant,*

on right hand fork of Clover creek of Cumberland river, Harlan county. Upper coal measures. Collected by R. C. Ballard, August 28, 1884. Coal six feet ten inches thick to sandstone roof."

A bright, firm, pure-looking coal. No pyrites and but little fibrous coal apparent. Very imperfectly laminated. Some pieces with ferruginous incrustation. It softens and swells somewhat on burning. It approaches bituminous coal in character, and would no doubt make very good coke.

No. 2478 (*b*) —COAL: "*From Elijah Creech's bank, two and a half miles above the mouth of Looney creek of Rock Fork of Cumberland river, Harlan county. Upper coal measures. Collected by R. C. Ballard, August 23, 1884. The sample was taken from the upper seventy-one and a half inch layer, which is separated by a two inch parting from a lower six inch layer of coal.*"

A bright, pure-looking coal; of irregular cuboidal and lamellar fracture. Contains some little fibrous coal and a small quantity of fine granular pyrites between the irregular lamellæ. Softens and swells somewhat in burning. Would doubtless make good coke.

No. 2478 (*c*)—COAL: "*From head of Wallen's creek, five miles from the Cumberland river, Harlan county. Collected by by R. C. Ballard, August 1, 1884. The sample was taken from the upper eighty-six inch layer only, which had a small clay parting nineteen inches from its bottom. Another five inch layer of coal, separated from the above by a seven inch clay parting, lies under this thick layer.*"

A pure-looking, bright coal; not easily cleaving into irregular laminæ. Shows very little fibrous coal and no apparent pyrites.

COMPOSITION OF THESE HARLAN COUNTY COALS.

(*Air-dried.*)

	No. 2478 (*a.*)	No. 2478 (*b.*)	No. 2478 (*c.*)
Specific gravity	1.264	1.198	1.307
Hygroscopic moisture	2.60	1.46	2.20
Volatile combustible matters	35.60	35.34	35.10
Coke	61.80	63.20	62.70
Total	100.00	100.00	100.00
Total volatile matters	38.20	36.80	37.30
Carbon in the coke	58.60	61.80	56.70
Ash	3.20	1.40	6.00
Total	100.00	100.00	100.00
Character of the coke	Dense spongy.	Dense spongy.	Spongy.
Color of the ash	Lt. purp. grey.	Lt. purp. grey.	Grey buff.
Percentage of sulphur	0.491	0.497	0.818

These coals, of the so-called splint or semi-cannel variety, are remarkably pure and good, more especially 2478 (*a*) and 2478 (*b*), containing quite a small proportion of sulphur and leaving much less than the average amount of ash; indeed, among the hundreds of samples of Kentucky coals which have been analyzed during the progress of the Geological Survey only seven gave as small a proportion of ash as No. 2478 (*b*). These coals would no doubt yield coke of best quality, and prove admirably suitable for the smelting and working of iron.

HOPKINS COUNTY.

No. 2479—COKE: "*From Crab Tree coal.* (*Coal No. 12.*) *Coked in an open fire, out of slack coal. The slack was not picked or washed, but taken as it came through the screen bars. Sample sent by F. S. Isley, Dawson, Hopkins county. Received April, 1884.*"

A firm, bright, cellular coke. Some small fragments of shale in the sample.

COMPOSITION (*Air-dried*).

Moisture and volatile matters expelled on ignition	1.70
Fixed carbon	81.10
Purple-grey ash	17.20
Total	100.00

Its percentage of sulphur is 4.35.

No doubt a much better coke could be made of this slack after it has been properly washed.

LAUREL COUNTY.

No. 2480—COKE: "*Made of coal sent from Pitman's Station, on the Knoxville branch of the Louisville & Nashville Railroad. (Peacock Post-office.) Geological position, lowest bed of the coal measures. Coked January 26–29, 1884, by R. C. Ballard in 66 hours.*"

A firm, cellular coke, somewhat irregular in structure. Contains some shale, and the outside surfaces of some of the pieces seem to have been burnt or partly incinerated.

No. 2481—COKE: "*From coal sent from the same station as the last described sample. Geological position same as that. Coked by R. C. Ballard, January 29–31, 1884, in 42 hours.*"

Resembles the preceding, with less appearance of external incineration.

COMPOSITION (*Air-dried*).

	No. 2480	No. 2481
Moisture and volatile matters lost on ignition	1.60	1.30
Fixed carbon	92.20	89.80
Ash	6.20	8.90
Total	100.00	100.00
Color of the ash	Lt. grey.	Reddish brown.
Percentage of sulphur	1.000	1.274

LAWRENCE COUNTY.

No. 2482—COAL: "*From Big Wolf-Pen Fork of Nat's creek.*

Average sample from the upper three feet. Whole thickness six feet six inches. 'Richardson coal.' Collected by A. R. Crandall, October 22, 1883."

Generally a dull-black coal, imperfectly laminated, showing some little fibrous coal, but no apparent pyrites. Contains some thin veins and pieces of brighter, blacker coal. Portions imperfectly granular in appearance.

No. 2483—COAL: "*From the same locality as the preceding. Average sample from the lower three feet. No parting. Six inches at the top of the same quality. Collected by A. R. Crandall, October 22, 1883.*"

This sample contains more of the bright, black coal of cuboidal and irregular fracture than the preceding. Some portions are dull black and laminated, with some fibrous coal between, but with no apparent pyrites. Ferruginous incrustation on some exterior surfaces.

COMPOSITION OF THESE LAWRENCE COUNTY COALS.

(*Air-dried.*)

	No. 2482	No. 2483
Specific gravity	1.424	1.408
Hygroscopic moisture	0.40	0.40
Volatile combustible matters	31.00	30.80
Coke	68.60	68.80
Total	100.00	100.00
Total volatile matters	31.40	31.20
Carbon in the coke	50.64	48.50
Ash	17.96	20.30
Total	100.00	100.00
Character of the coke	Friable.	Dense.
Color of the ash	Lt yel'w-ish grey.	Lt purp-lish grey
Percentage of sulphur	0.642	0.821

The large percentage of ash in these coals diminishes their value.

LETCHER COUNTY.

Coals.

No. 2483 (*a*)—COAL: "*On the land of Wilson Lewis, on Roberts' branch of Poor Fork of Cumberland river, one mile below Partridge postoffice. Lower coal measures. Collected by R. C. Ballard, September 1, 1884. The bed consists of a fifty-four inch layer of coal separated, by a two inch parting, from another layer of coal forty-one inches thick, under which is a ten inch layer of coal separated by a one inch parting.*"

The sample seemed, from its weathered appearance, to have been taken from the outcrop. It softens and swells somewhat in burning.

No. 2483 (*b*)—COAL: "*From below the two inch parting; same bed as the next preceding. Collected by R. C. Ballard, September 1, 1884.*"

Seems also to be a weathered sample. Softens and swells considerably in burning.

COMPOSITION OF THESE LETCHER COUNTY COALS.

(*Air-dried.*)

	No. 2483 (*a.*)	No. 2483 (*b.*)
Specific gravity	1.278	1.225
Hygroscopic moisture	2.50	2.06
Volatile combustible matters	30.94	33.18
Coke	66.56	64.76
Total	100.000	100.000
Total volatile matters	33.44	35.24
Carbon in the coke	57.75	59.26
Ash	8.81	5.50
Total	100.000	100.000
Character of the coke	Dense.	Spongy.
Color of the ash	Lt. buff grey.	Lt. grey buff.
Percentage of sulphur	0.629	0.790

Although giving a little more than the average ash percentage, these coals, containing but a relatively small proportion of sulphur, are quite good and valuable for most purposes.

LEWIS COUNTY.

No. 2484—LIMESTONE (HYDRAULIC?): "*Sent to Mr. Procter by Mr. W. J. Richason, of Vanceburg, Lewis county.*"

A dull-grey, fine-granular rock, with faint lines of stratification. Adheres slightly to the tongue.

COMPOSITION (*Air-dried*).

Lime carbonate	48.790=27.322 lime.
Magnesia carbonate	37.482=17.834 magnesia.
Iron oxide and alumina	2.490
Phosphoric acid (P2 O5)	.143
Potash	.490
Soda	.058
Soluble silica	1.150
Insoluble silica and silicates	8.850
Moisture and loss	.547
Total	100.000

This is a magnesian or dolomitic limestone. Some limestones of this character yield pretty good hydraulic cement. It is stated on good authority that dolomitic limestone, if calcined at a red heat only, so that the carbonic acid may be driven off from the magnesia and not from the lime, will harden under water; but if calcined at a white heat, so as to drive off the carbonic acid from the lime, it loses this property. Such cement, it is said, is poor and does not bear admixture with sand.

On the other hand, it is stated on good authority that if such limestone be heated high enough to sinter (*i. e.* to undergo partial fusion) for ten or twelve hours—when the magnesia will form a silicate—it makes a good cement which may be mixed with sand.

The writer is disposed to believe that this apparent difference depends on the chemical composition of the limestone, and that the first statement may prove to be correct as to a *pure* dolomitic limestone, which contains little or no silica (especially soluble silica) or alumina and iron oxide and the alkalies; but that the second statement would be verified by properly calcining a dolomitic limestone, which, like the one above described, from Lewis county, contains these essential ingredients in sufficient amount.

This supposition was rendered probable by calcining some of this limestone—first at a moderate red heat, which produced a slowly hardening cement which would not bear admixture with sand; then by calcining it at a high temperature; the result of which was a cement which hardened more quickly when mixed with water, and became harder when left for some time in contact with that fluid than the sample calcined at the lower heat.* Whether it would bear admixture with sand was not tried. The rock is worthy of a trial on a larger scale.

LYON COUNTY.

No. 2485—BITUMINOUS LIMESTONE: "*From the land of Colonel Machen, near Eddyville, Lyon county. Is it hydraulic?*"

*Since the above was written, the sample, allowed to remain under water for some weeks, then allowed to become dry and again placed under water, became and remained very hard, showing that properly managed this rock would make good hydraulic cement.

A dark-slate-colored, compact limestone. Fracture broad irregular conchoidal. Does not adhere to the tongue.

COMPOSITION (*Air-dried*).

Lime carbonate	85.580=47.925 lime.
Magnesia carbonate	2.088
Alumina, iron oxide, etc.	.680
Potash	.251
Soda	.178
Silica and insoluble silicates	9.580
Bitumen, moisture and loss	1.643
Total	100.000

This would not probably make hydraulic cement, but it calcines into very good white lime.

MADISON COUNTY.

No. 2486—SOIL (CULTIVATED): "*Taken to the depth of ten inches below the surface; from land of William Gibson, near Richmond, close to the Lancaster turnpike. On the upper Hudson beds. Collected by Moritz Fischer, June 23, 1884.*"

The dried soil is quite friable, of a light umber color. It all passed through the coarse seive,* except 2.16 per cent. of small ferruginous and cherty concretions. Its silicious residue after digestion in acids all passed through the fine seive.†

No. 2487—SUBSOIL (OF THE PRECEDING, ETC., ETC.): "*Taken from ten down to twenty inches below the surface, from the same locality.*"

Slightly lighter colored than the preceding, and the clods are somewhat more firm. All passed through the coarse seive except 1.71 per cent. of small ferruginous and cherty concretions. Its silicious residue all passed through the fine seive except a few small quartzose particles.

No. 2488—SOIL (CULTIVATED): "*Taken down to ten inches below the surface, on the land of Mr. Steve Walker, near his farm, three hundred yards to the right of Paint Lick turnpike. On black shale formation. In a local 'glade—marshy ground. Collected by Moritz Fischer, June 20, 1884.*

*With 64 meshes to the centimeter square.

†With 1600 meshes to the square centimeter.

Soil of a grey-black color. Clods friable, containing small rootlets. All passed through the coarse seive except about 0.55 per cent. of small ferruginous concretions. Its silicious residue all passed through the fine seive. Soil said to be cold and unproductive, but benefited by top-dressing with lime.

No. 2489—SUBSOIL (OF THE NEXT PRECEDING): "*Taken from ten inches down to the depth of twenty inches from the surface, etc., etc.* (*as next preceding*)."

Subsoil in firm clods; quite clayey; of a grey color, mottled with orange and red ferruginous or ochreous. All passed through the coarse seive except 0.91 per cent. of small ferruginous concretions. Its silicious residue all passed through the fine seive.

No. 2490—SOIL (CULTIVATED): "*Taken down to ten inches below the surface, on the land of S. Fitzpatrick, near Walnut Meadow and Big Hill Turnpike, four miles northwest of Berea. On middle Hudson beds. Collected by Moritz Fischer, June 24, 1884.*"

Soil of a brownish-yellowish color; clods moderately firm. All passed through the coarse seive except 0.21 per cent. of very small ferruginous concretions. Its silicious residue all passed through the fine seive except very few small quartz grains.

No. 2491—SUBSOIL (OF THE NEXT PRECEDING): "*Taken at from ten inches down to twenty inches from the surface, etc., etc.*"

Slightly more yellowish and lighter colored than the next preceding. Clods firm; mottled with blackish. All passed through the coarse seive except 0.36 per cent. of very small ferruginous concretions. Its silicious residue all passed through the fine seive except very few small quartz grains.

No. 2492—SOIL (CULTIVATED): "*Taken to the depth of ten inches below the surface, on the north slope of the College Campus at Berea, more than six hundred feet from the glades. On black shales. Collected by Moritz Fischer, June 17, 1884.*"

Soil of a dirty brownish yellow color. Clods moderately firm. All passed through the coarse seive except 4.93 per cent. of small ferruginous and cherty concretions and fragments. Of its silicious residue all passed through the fine seive except a very few small quartz grains.

No. 2493—SUBSOIL (OF THE NEXT PRECEDING): "*Taken at ten to twenty inches below the surface; same locality, etc., etc.*"

Slightly more yellowish than the preceding. The coarse seive removed from it 3.64 per cent. of small ferruginous and cherty concretions. Its silicious residue all passed through the fine seive except very few small quartz particles.

No. 2494—SOIL (CULTIVATED): "*Taken to the depth of ten inches beneath the surface, on the land of John Davis, three miles south of Berea, near the Scaffold Cane road. On the Waverley group, near the horizon. Collected by Moritz Fischer, June 16, 1884.*"

Soil in firm clods, of a light greyish yellow ochre color. The coarse seive removed from it 8.17 per cent. of irregular fragments of ferruginous sandstone and ferruginous concretions. Its silicious residue all passed through the fine seive except very few small quartz grains.

No. 2495—SUBSOIL (OF THE NEXT PRECEDING): "*Taken at ten to twenty inches below the surface; same locality as that, etc., etc.*"

The coarse seive removed from it 12.13 per cent. of irregular fragments of ferruginous sandstone and small concretions. Its silicious residue all passed through the fine seive except very few small silicious particles.

COMPOSITION OF THESE MADISON COUNTY SOILS.

(Dried at 212° F.)

	No. 2486	No. 2487	No. 2488	No. 2489	No. 2490	No. 2491	No. 2492	No. 2493	No. 2494	No. 2495
Organic and volatile matters	5.683	4.213	12.677	5.671	4.008	3.554	3.874	3.678	2.971	2.055
Alumina and manganese oxide	5.588	4.618	12.227	9.789	6.012	6.295	5.171	4.990	3.880	6.986
Iron peroxide	4.173	4.000	3.604	8.865	5.011	5.484	4.337	3.792	3.245	4.655
Lime carbonate	.768	.612	.073	.073	.508	.381	.107	.082	.106	.052
Magnesia	.478	.414	.401	.529	.677	.462	.242	.265	.300	.466
Phosphoric acid (P_2O_5)	.304	.251	.235	.072	.128	.118	.095	.078	.030	.040
Potash, extracted by acids	.427	.447	.543	.133	.435	.491	.344	.312	.242	.692
Soda, extracted by acids	.065	.072	. .	. .	. .	. .	. .	. .	. .	. .
Water, expelled at 360° F.	1.126	.944	2.248	1.657	1.058	1.030	.926	.628	.634	.492
Sand and insoluble silicates	81.802	83.753	68.031	72.504	82.040	82.240	84.468	86.185	88.756	84.926
Totals	100.414	99.324	100.042	99.291	99.877	100.055	99.564	100.010	100.114	99.464
Hygroscopic moisture,	2.350	2.100	4.834	2.585	2.615	2.925	2.300	2.135	1.550	2.440
Potash, in the silicious residue	1.867	1.959	1.365	1.722	1.964	1.848	3.468	1.897	1.935	1.527
Soda, in the silicious residue	.236	.367	.127	.092	.504	.281	.273	.260	.418	.541
Character of the soil	Upper soil.	Subsoil.	Upper soil.	Subsoil.	Upper soil.	Subsoil.	Upper soil.	Subsoil.	Upper soil.	Subsoil.

These soils, taken to depths, severally, of ten and twenty inches from the surface, are all from ground which is under cultivation. Nos. 2486 and 2487 are located on the upper Hudson beds. Nos. 2490 and 2491 are on the middle Hudson. Nos. 2488, 2489, 2492 and 2493 are on black shale, and Nos. 2494 and 2495 on the Waverley group.

The richest of all are those located on the upper and middle Hudson beds. The soils of both these formations are especially rich in potash, lime and magnesia. The upper Hudson soil especially excels in its proportion of phosphoric acid, the soil of the lower Hudson having a good average only of this essential element. These can not fail to be quite productive if they are sufficiently drained and properly cultivated.

The soils Nos. 2488 and 2489 are located, like Nos. 2492 and 2493, on black shale; but the former—2488 and 2489—one in a local "glade," so-called—marshy ground, imperfectly drained, and contain an excess of clay material and of organic matters in a peaty condition, giving it a blackish color and causing it to hold much moisture. Both the upper soil and the subsoil are remarkably deficient in lime, and the subsoil is very poor in phosphoric acid. Although the upper soil contains a very large proportion of potash and enough phosphoric acid, it is unproductive because of the want of lime in its composition and its excess of moisture. It is said that top-dressing of lime greatly improves it. But thorough drainage, with the use of lime and phosphatic manures, will make both soil and subsoil fertile.

Nos. 2492 and 2493, also on the black shale formation, are especially deficient in phosphoric acid, and also require lime. If they are well drained, the use of phosphatic manures and lime will make and keep them productive.

Nos. 2494 and 2495, on the Waverley group, are poorest in phosphoric acid of all these soils. They also want lime. Phosphatic fertilizers, with lime and sufficient drainage, are all they require to make them productive with good husbandry.

All these soils are in a state of very fine division, containing no coarse sand or gravel, generally speaking. Hence they are

easily penetrated by the aeriform agents of fertility, and hold moisture very well, especially when care is taken to keep a sufficient amount of humus in the soil. When this is the case, and alkalies and lime and magnesia are present in the soil, nitrates and other nitrogen compounds are spontaneously produced, by aid of the atmospheric agencies, sufficient to furnish the essential nitrogen to most field crops.

Clays of Madison County.

No. 2496—SHALEY CLAY: "*From land of F. W. Lewis, two miles south of Bobtown, about one hundred yards to the left of Big Hill turnpike, almost opposite the blacksmith shop of F. W. Lewis. Bed four to five feet thick. On Niagara shale. Sample of the upper ten inches. Collected by Moritz Fischer, June 21, 1884.*"

A laminated clay or soft shale, of a light-grey color on the exterior; darker colored and brownish-yellowish-grey in the interior.

No. 2497—SHALEY CLAY: "*From the same locality as the preceding, etc., etc. Sample from ten to twenty inches below the surface. Collected by M. Fischer, etc., etc.*"

Darker colored than the preceding; of a light olive-green color.

These clays, analyzed by fusion, etc., showed the following

COMPOSITION.

(*Air-dried.*)

	No. 2496	No. 2497
Silica	59.000	42.560
Alumina and iron oxide	*24.640	20.980
Lime	1.456	8.680
Magnesia	1.096	7.247
Potash	5.500	4.819
Soda	.217	.166
Water, carbonic acid and loss	8.091	15.548
Total	100.000	100.000

*Containing 20.68 per cent. of alumina, etc., and 3.96 per cent. f iron peroxide.

A small quantity of titanic acid was found in No. 2497. The other sample was not tested for this substance.

No doubt common pottery ware and terra cotta could be made of this clay, ground and properly tempered with water. It contains too much of potash, lime and iron oxide for a fire-clay.

If its potash were not in close chemical combination with the other elements of this clay, it might be useful as a fertilizer. Its only profitable application for this purpose would be to a very light sandy soil not far distant from the clay, as it would not pay for distant transportation.

No. 2498—PLASTIC CLAY: "*From the land of Gordon Glasgow slope of Bare Knob, three miles south of Berea, Madison county, Waverley clay, near the Conglomerate. Collected by Moritz Fischer, July 1, 1884.*"

A light-grey, plastic clay. Calcines of a light-reddish color. Fuses before the blowpipe.

COMPOSITION.

	Air-dried.	Calculated dried at 212° F.
Silica	48.000	49.689
Alumina	18.380	19.026
Iron peroxide	3,900	3.932
Lime carbonate	1.600	*1.656
Magnesia carbonate	4.033	†4.172
Potash	3.797	3.827
Soda	.276	.288
Water and loss	20.014	17.410
Total	100.000	100.000

*Equal to 0.927 per cent. of lime. †Equal to 1.960 per cent. of magnesia.

This clay could be used for the manufacture of various kinds of common pottery ware, terra cotta products, etc.

No. 2499—MARLY SHALE: "*On the land of John Pigg, four miles south of Berea, near the road from Berea to the Big Hill Turnpike, by the way of Bobtown. The locality is called Blue Lick. Waverley formation, resting on black shale. Said to be a good fertilizer on black shale and Waverley soils. Collected by Moritz Fischer, August 16, 1884.*"

COMPOSITION.

	Air-dried.	Calculated dried at 212° F.
Silica	68.440	69.152
Alumina and iron oxide	20.180	20.390
Phosphoric acid (P_2O_5)	a trace.	a trace.
Lime carbonate	.144	.145
Magnesia carbonate	2.860	2.289
Potash	8.678	8.754
Soda	.740	.747
Hygroscopic moisture	1.030	. . . .
Combined water and loss	2.947	2.920
Total	100.000	100.000

As experience seems to have demonstrated to a certain extent, this shale might be advantageously applied as a top-dressing to poor, sandy soils. But it would not pay to transport it to any considerable distance, especially because its potash, although in quite notable proportion, would be slowly available only, it being in pretty firm combination with the silicates; and moreover, its phosphoric acid is in small proportion. Exposed to moisture, frost, and the atmospheric agencies generally, it would soon disintegrate into a clay. Pulverized and kneaded with water, it would be plastic enough to be used for common pottery-ware.

MONTGOMERY COUNTY.

No. 2500—PHOSPHATIC LIMESTONE (?): "*Sample from the top, middle and bottom layer, two feet thick, on the farm of Dr. L. C. Jeffries, northwestern part of Montgomery county, sixty feet above Aaron's run. This rock is used as a building stone. It easily splits into thin layers. Seems to be phosphatic.*"

A somewhat granular limestone, irregularly fine-crystalline, with a cementing material of a brownish-yellowish-grey color. Does not adhere to the tongue. No distinct appearance of fossil remains in it.

Analyzed specially for phosphoric acid, by the molybdic process, it gave only 0.493 per cent. of that substance.

Soils of Montgomery County.

No. 2501—VIRGIN SOIL: "*From the farm of Dr. L. C. Jeffries,*

near Aaron's run; taken to the depth of eleven inches. Formation, middle Hudson beds. Timber, largely sugar tree. Collected by W. M. Linney, May 10, 1884."

Soil partly in friable clods, of a light grey-brown color. The coarse seive removed from it about 4.6 per cent. of small ferruginous concretions. Its silicious residue from digestion in acids all passed through the fine seive.

No. 2502—SUBSOIL (OF THE PRECEDING, ETC., ETC.): "*Taken from eleven to twenty inches beneath the surface.*"

This subsoil is in firm clods. It resembles the next preceding in color. All passed through the coarse seive except about 5 per cent. of small ferruginous concretions.

No. 2503—SOIL: "*From a field seventy-five years in cultivation, in the same farm and ridge as the two next preceding samples. Taken to the depth of eleven inches. Collected by W. M. Linney, etc., etc. (Middle Hudson.)*"

Resembles the next preceding. The coarse seive removed from it about 1.9 per cent. of small ferruginous concretions. Its silicious residue all passed through the fine seive except one or two minute quartz grains.

No. 2504—SUBSOIL (OF THE NEXT PRECEDING): "*Taken from eleven to twenty inches beneath the surface. By W. M. Linney, etc., etc.*"

Partly in friable clods; color slightly lighter than of the preceding soils. The coarse seive removed from it about 6 per cent of small ferruginous concretions. All its silicious residue passed through the fine seive.

No. 2505.—VIRGIN SOIL: *Taken from the first eleven inches in depth from a woodland pasture, farm of Joshua Owings, near the Mount Sterling and Owensville turnpike; six miles from Mount Sterling. Upper Hudson, on the Orthis Lynx beds. Timber: Blue and white ash, yellow chestnut, red and laurel oak, wild cherry, hackberry, black walnut and*

sugar tree. (All indicate rich soil.) Collected by W. M. Linney, May 7, 1884."

The coarse seive removed from it only about 1.17 per cent. of small ferruginous concretions (shot iron ore). Its silicious residue all passed through the fine seive except a small quantity of small white grains of milky quartz of irregular, flattened shape.

No. 2506—SUBSOIL (OF THE NEXT PRECEDING): "*Taken eleven to twenty inches beneath the surface, etc., etc. Collected by W. M. Linney, etc., etc.*"

Dried subsoil somewhat lighter in color than the preceding. Clods small and somewhat firmer. It all passed through the coarse seive except only 0.38 per cent. of shot iron ore, etc. The silicious residue all passed through the fine seive except a small quantity of fine sand of milky quartz, in irregular, not rounded particles.

No. 2507—SURFACE SOIL: "*From a field cultivated for at least seventy-five years, on the opposite side of the turnpike from the preceding soils, on the farm of General Dick Williams. Sample taken to the depth of eleven inches. Collected by W. M. Linney, May 7, 1884.*"

The dried soil resembles No. 2505, but is slightly lighter colored and more yellowish-brown. Clods small; not quite as friable as the clods of that soil. All passed through the coarse seive except about 2.01 per cent. of shot iron ore and small fragments of chert. Its silicious residue all passed through the fine seive except a small quantity of fine sand of milky quartz, not much rounded.

No. 2508—SUBSOIL (OF THE NEXT PRECEDING): "*Taken eleven to twenty inches beneath the surface. Collected by W. M. Linney, May 7, 1884.*"

Dried subsoil of a yellowish light-grey-brown color, somewhat lighter colored than No. 2506. Its small clods are firm. All passed through the coarse seive except 1.71 per cent. of small shot iron ore. Its silicious residue all passed through the fine seive except a small quantity of fine white sand, of grains not much rounded.

COMPOSITION OF THESE MONTGOMERY COUNTY SOILS.

(*Dried at 212° F.*)

	No. 2501	No. 2502	No. 2503	No. 2504	No. 2505	No. 2506	No. 2507	No. 2508
Organic and volatile matters	3.955	3.387	3.908	3.208	5.495	4.092	5.160	3.816
Alumina and manganese oxide	5.088	6.120	4.441	7.037	4.885	7.992	5.597	5.478
Iron peroxide	4.210	4.370	6.220	4.870	4.365	5.566	4.540	5.360
Lime carbonate	.482	.457	.365	.305	.622	.718	.400	.319
Magnesia	.349	.410	.351	.393	.332	.588	.229	.178
Phosphoric acid (P_2O_5)	.193	.184	.300	.238	.315	.261	.260	.157
Potash extracted by acids	.487	.406	.399	.482	.256	.610	.335	.526
Soda extracted by acids	. .	.077	.124	. .	.265	. .	.276	.279
Water expelled at 360° F.	.677	.658	.632	.688	1.425	1.176	1.382	1.246
Sand and insoluble silicates	84.906	84.209	83.212	82.733	82.284	78.883	82.121	83.169
Total	100.292	100.277	99.961	99.904	100.244	99.836	100.300	100.528
Hygroscopic moisture	2.540	2.760	2.785	3.870	2.825	3.250	2.425	2.915
Potash in the silicious residue	1.803	1.925	1.853	1.837	1.629	1.444	1.189	1.105
Soda in the silicious residue	.372	.421	.489	.414	.323	.277	.239	.206
Character of the soil	Virgin soil.	Subsoil.	Old field soil.	Subsoil.	Virgin soil.	Subsoil.	Old field soil.	Subsoil.

All of these soils, based on the middle and upper Hudson beds, are types of fertile soils. Those on the middle Hudson are only slightly more rich in some essential ingredients than those on the upper Hudson formation. Their subsoils are richer in potash than the surface soils, but phosphoric acid is generally in larger proportion than the surface soils.

MORGAN COUNTY.

No. 2509—CANNEL COAL: "*From Elk Fork of Licking river. Average thickness of the bed, three to four feet. Sample sent by Mr. J. M. Bent, November 6, 1883.*"

A firm, tough, dull black coal, showing imperfect laminations. Shows no fibrous coal, but contains a nodule of iron pyrites.

COMPOSITION (*Air-dried*).

Specific gravity			1.253
Hygroscopic moisture	1.40	Total volatile matters	51.46
Volatile combustible matters	50.06		
Dense coke	48.54	Carbon in the coke	40.14
		Grey-brown ash	8.40
Total	100.000	Total	100.000
Percentage of sulphur			1.65

It appears to be a good cannel coal.

MUHLENBERG COUNTY.

No. 2510—COKE: "*Made of a sample of coal sent by the Central Coal and Iron Company of Louisville, from the line of C. & O. & S. W. R. R., Muhlenberg county.*" *Geological position of the coal, No. 9, Western coal field. Coke made by R. C. Ballard, January 28–30, 1884.* (*Forty-eight hours.*)"

Coke bright and fine cellular; firm; irregularly columnar.

COMPOSITION (*Air-dried*).

Moisture and volatile matters	1.50
Fixed carbon	90.54
Purple-brown ash	7.96
Total	100.000

Its percentage of sulphur is 2.469.

The sulphur, which is rather above the average in good coke, may be partly in the ash and partly in the fixed carbon.

PIKE COUNTY.

No. 2511—COAL: "*From Big Rock Hollow of Bear Fork of Robinson creek. Forty or fifty feet above the thirty-two inch coal. Bed, with shale roof; has twenty-seven and a half inches of coal on top, separated by a fire-clay parting of nine inches from the lower layer of twenty-five inches of coal. Sample collected from the upper twenty-seven and a half inch coal, by R. C. Ballard. October 13, 1883.*"

Generally a bright, pitch-black coal, irregularly and imperfectly laminated. Contains very little fibrous coal and no apparent pyrites.

No. 2512—COAL: "*From the same bed as the preceding. Sample from the lower twenty-five inches. Collected by R. C. Ballard, October 13, 1883.*"

Resembles the next preceding, but is rather brighter and darker colored. Both samples contain much pounded and powdered coal.

No. 2513—COAL: "*From Big Rock Fork of Bear Fork, a mile and a half above the mouth where it empties into Robinson creek, of Shelly creek. Bed of coal thirty-two inches thick. The upper two inches not included in the sample. Collected by R. C. Ballard, October 3, 1883.*"

Apparently a weathered sample. Contains much powdered coal and some pieces with ferruginous incrustation. Laminated structure. Very little fibrous coal and no pyrites apparent.

No. 2514—CANNEL COAL: "*From Bear Fork of Robinson creek of Shelly creek. (Widow May's cannel coal.) Bed with thirty-three inches of bituminous coal on top, separated by a two and a half inch parting from sixteen and a half inches of bituminous*

coal below, under which lies the cannel coal, thirty-three inches thick, with a one to three inch parting. The sample was taken excluding the parting. Collected by R. C. Ballard, October 12, 1883."

A laminated cannel coal; coated with clay on the exterior surfaces. Appears to be a weathered sample. Shows no pyrites.

No. 2515—COAL: "*Wm. Hull's bank, on the left hand fork of Indian creek, about four and a half miles above where it flows into Shelly creek. Bed, with a sandstone roof, forty-eight inches thick; the lower five inches covered by water, so that this part does not appear in the sample. Collected by R. C. Ballard, October 27, 1883.*"

A bright, pitch-black, shining coal; irregularly and imperfectly laminated. Shows no pyrites and very little fibrous coal.

No. 2516—COAL: "*From Jackson Newson's bank, on Robinson creek, seven miles above where it flows into Shelly creek and nineteen miles from Pikeville. Bed with a sandstone roof. Upper fifteen inches of coal included in the sample. Separated by a seven inch parting, not included, from a five and a half inch layer of coal, a one and a half inch to zero parting, and a lower twenty-four inch layer of coal; all three included in the sample. Collected by R. C. Ballard, September 27, 1883.*"

A bright, pitch-black, splint coal; irregularly laminated. Some fibrous coal between some of the laminæ, but no apparent pyrites.

COMPOSITION OF THESE PIKE COUNTY COALS.

(*Air-dried.*)

	No. 2511	No. 2512	No. 2513	No. 2514	No. 2515	No. 2516
Specific gravity	1.294	1.278	1.310	1.293	1.294	1.311
Hygroscopic moisture	0.40	0.40	1.60	2.00	0.60	1.00
Volatile combustible matters . .	33.20	34.80	30.80	43.40	33.94	34.20
Coke	66.40	64.80	67.60	54.60	65.46	64.80
Total	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	33.60	35.20	32.40	45 40	34.54	35.20
Fixed carbon in the coke . . .	62.46	60.46	62.80	46.30	59.46	58.90
Ash	3.94	4.34	4.80	8.30	6.00	5.90
Total	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Dense spongy.	Spongy.	Dense.	Pulverulent.	Light spongy.	Spongy.
Color of the ash	Lt. salmon col.	Salmon colored.	Dark salmon col.	Salmon colored.	Reddish grey.	Grey.
Percentage of sulphur	0.642	0.711	0.555	0.689	0.876	0.903

All these are quite good coals; Nos. 2514, 2515 and 2516 leave the most ash.

ROCKCASTLE COUNTY.

No. 2517—SOIL: "*Upper ten inches in depth, from F. W. Hauskin's farm, crossing of Scaffold Cane and Ridge roads. On the conglomerate formation. Collected by Fischer and Morgan, June 14, 1884.*"

Clods moderately firm, of a brownish-yellow color. The coarse sieve removed from it 4.04 per cent. of small ferruginous concretions. Its silicious residue all passed through the fine sieve except a small quantity of fine quartz sand.

No. 2518—SUBSOIL (OF THE PRECEDING SOIL): "*Taken at ten to twenty inches beneath the surface. By Fischer & Morgan, June 14, 1884.*"

Subsoil generally lighter colored than the upper soil; of a light-greyish-yellow color, mottled with reddish. The coarse sieve removed from it 1.73 per cent. of ferruginous concretions.

No. 2519—SOIL: "*Upper ten inches in depth, from land of Charles Lester; fifty feet above the crossing of the Reedsville and Mt. Vernon roads. On St. Louis limestone formation. Collected by Moritz Fischer, June 16, 1884.*"

Soil in moderately firm clods, of a light brick color. The coarse sieve removed from it 3.32 per cent. of rounded quartz pebbles and ferruginous concretions. The fine sieve separated from its silicious residue 0.36 per cent. of fine white silicious sand.

No. 2520—SUBSOIL: "*Of the next preceding, taken at the depth of ten to twenty inches below the surface. Collected by Moritz Fischer, June 16, 1884.*"

In moderately firm clods of a handsome dark brick-red color. (This and the surface soil might serve as a cheap pigment. When calcined, the subsoil becomes of a good venetian red color.) The coarse sieve removed from the subsoil 4.49 per cent. of rounded quartz pebbles and small ferruginous concretion. The fine sieve separated from the silicious residue 0.356 per cent. of fine white quartzose sand.

COMPOSITION OF THESE ROCKCASTLE SOILS.

(*Dried at 212° F.*)

	No. 2517	No. 2518	No. 2519	No. 2520
Organic and volatile matters	2.794	3.414	3.178	4.505
Alumina and manganese oxide	5.293	2.308	7.694	11.403
Iron peroxide	2.382	1.392	3.584	5.690
Lime carbonate	.081	trace.	.112	.077
Magnesia	.127	.045	.183	.185
Phosphoric acid (P_2O_5)	.045	.055	.056	.033
Potash extracted by acids	.290	.245	.211	.345
Soda extracted by acids	....	....	....	....
Water expelled at 360° F.	.339	.217	.340	.308
Sand and insoluble silicates	88.469	92.499	83.951	77.028
Total	99.770	100.175	99.769	100.083
Hygroscopic moisture	1.175	1.210	1.675	2.900
Potash in the silicious residue	.570	.810	.259	.243
Soda in the silicious residue	.115	.137	.040	.097
Percentage of gravel and concretions	4.040	1.730	3.320	4.490
Character of the soil	Surface soil.	Subsoil.	Surface soil.	Subsoil.

These may be considered poor soils, because of their very small proportions of phosphoric acid and lime, with the exception that No. 2519, the surface soil on the St. Louis limestone, contains nearly an average quantity of lime. The proportions of sand and insoluble silicates are especially large in the soils of the conglomerate formation; and while the proportion of the alkalies, potash and soda are small in the silicious residue of all four samples, those in the soils of the St. Louis limestone formation are remarkably so. These latter soils excel in alumina and iron oxide, especially the subsoil, which might, if finely ground, be employed as a cheap pigment, especially after calcination. The oxide of iron gives to these their red color, and is active in the soil in causing oxidation of vegetable matters and in aiding in the production of nitrates.

Although naturally poor, these soils may be made quite productive by the judicious use of fertilizers, provided they are properly drained. Lime, or ground limestone, and phosphatic manures would no doubt be found to be eminently useful, together with stable manure or other organic material. But con-

tinued productiveness would depend on constant application of the manures. As is the case in Florida and other southern regions, where in some parts the so-called soil and subsoil are almost pure quartz sand, although a high productiveness may be maintained by the use of manures, the crops require to be continually fed by artificial fertilizers.

In the appendix some analyses of so-called soil from Florida are given, for comparison with our rich Kentucky soils, on some of which heretofore no manures have been required in the production of a long succession of good crops—a happy condition for the farmer, which, however, can not last forever, except in unusually fortunate localities; as, for instance, on the soft rich beds of the Trenton or blue limestone formation. Even there the demand made on the soil in the production of heavy crops, more especially of tobacco, potatoes and garden products generally, proves to be greater in the long run than the natural supply, and the economy of the systematic use of manures and fertilizers becomes an important subject of study and practice.

WARREN COUNTY.

No. 2521—MINERAL WATER: "*Sent June 2, 1884, by Wm. H. Blakeley M. D., of Bowling Green; from a spring owned by him, seven miles from Bowling Green, on the Bowling Green and Hadley road, named Arcadia Spring. The spring flows out of a slaty layer, in about a three-inch stream.*"

COMPOSITION, *in 1000 Parts of the Water.*

Iron carbonate	0.061	Held in solution by carbonic acid.
Lime carbonate	.042	
Magnesia carbonate	.037	
Lime sulphate	.144	
Sodium chloride (and trace of carbonate)	.020	
Potassium chloride	.015	
Silica	.012	
Total saline matters	0.331	in 1000 parts of the water.

This appears to be a good weak chalybeate water, which

should be drank at the spring, as it will not long retain its iron carbonate when exposed to the air.

WHITLEY COUNTY.

No. 2522—Bituminous Indurated Clay: "*From a bed about five feet thick, which has, near its center, a four inch streak of what seems to be iron carbonate containing bright specks of pyrites. On the line of the Knoxville branch of the L. & N. R. R., near Brummitt's Station. Sample sent November 20, 1883, by Thos. W. Varnon, Esq., Mount Sterling, Ky.*

A soft shale or indurated clay, of a dark slate color, with some minute specks of mica, and in one of the pieces an impression of a reed-like leaf. Breaks in irregular, imperfect laminæ; is soft enough to be scratched by the nail. Does not soften much in water unless when pulverized, when it forms a very tough, plastic clay. Before the blowpipe it fuses with difficulty into a yellowish-grey, blebby mass.

Composition (*Air-dried*).

Silica	54.180
Alumina	25.360
Iron oxide	4.820
Lime	.549
Magnesia	1.614
Potash	4.286
Soda	.348
Water and bituminous matters	9.800
Total	100.000

It would answer, no doubt, for the manufacture of stoneware, as it burns of a buff-grey color, and many terra cotta and other varieties of pottery could be made of it. It contains too much potash, soda, lime, magnesia and iron oxide for a fire-clay.

No. 2523—Coke: "*Made of coal sent by J. S. Bury, one mile from Mahon Station, on the Knoxville branch of the L. & N. R. R. Whitley county. Coke made by R. C. Ballard, January 26 to 29, 1884.*"

A firm, irregularly columnar, fine cellular coke.

COMPOSITION (*Air-dried*).

Moisture and volatile matters excluded at a red heat	2.00
Fixed carbon	94.80
Light brick-colored ash	3.20
Total	100.00

The percentage of sulphur is 0.849.

This appears to be a very good coke.

No. 2524—COAL: "*An average sample from the whole face of the main seam, or bed; which is forty to forty-four inches thick, with a one inch parting, twenty inches from the top. Of the Jellico Mountain Coal and Coke Company, Kensee P. O., Whitley Co., Ky. Collected by A. R. Crandall, July 21, 1884.*"

A pure-looking, firm, pitch-black coal, showing very little fibrous coal or pyrites; only one small shining scale was seen in the sample.

COMPOSITION (*Air.dried*).

Specific gravity	1.286		
Hygroscopic moisture	1.90	Total volatile matters	84.76
Volatile combustible matters	82.86		
Spongy coke	65.24	Carbon in the coke	63.10
		Light brownish-grey ash	2.14
Total	100.00	Total	100.00
Percentage of sulphur	0.700		

A remarkably good and pure coal.

Other analyses of coal and coke of the Jellico Mountain Coal and Coke Company from a neighboring region in Tennessee are given in the preceding Report. (See Nos. 2456, 2457, 2458 and 2459.)

APPENDIX.

FLORIDA SOILS.

No. 2525—SURFACE SOIL (SO-CALLED): *"From a thrifty Orange Grove near Wellwood, Orange county, Florida. Sample brought by W. O. Sweeny, M. D., May 1884."*

Mostly fine-grained hyaline quartz sand, mixed with a small quantity of blackened and partly decomposed vegetable matter. Generally of a light-grey color. It all passed through the coarse sieve except about 0.8 per cent. of vegetable debris and a few larger grains of quartz sand.

No. 2526—SUBSOIL (SO-CALLED): *"Of the preceding to a depth of four feet. Sample by W. O. Sweeny, M. D.*

Generally of a brownish-light-grey tint. Contains a small proportion of vegetable remains, of which the coarse sieve removed only 0.35 per cent., leaving a small proportion too finely divided to be thus removed. It is mainly composed of fine sand of colorless, transparent quartz grains, somewhat rounded. Very few grains of milky and reddish quartz.

COMPOSITION (*Air-Dried*).

	No. 2525	No. 2526
Organic and volatile matters	1.075	0.550
Alumina, iron oxide and trace of phosphoric acid	.895	.425
Lime carbonate	.095	.070
Magnesia	.060	.053
Potash extracted by acids	.100	n. e.
Soda extracted by acids	.188	n. e.
Fine quartz sand	98.995	99.045
Total	100.858	100.143

A portion of the soluble ingredients is no doubt derived from the fertilizers which had been regularly applied to promote the growth of the orange trees, which were just coming into bearing.

TABLE I.—SOILS AND SUBSOILS (DRIED AT 212° F.)

Number	County.	Organic and volatile matters	Alumina and manganese oxide	Iron peroxide	Lime carbonate	Magnesia	Phosphoric acid	Potash extracted by acids	Soda extracted by acids	Water expelled at 360°	Sand and silicates	Hygroscopic moisture	Potash in siliceous residue	Soda in siliceous residue	Gravel, etc.	Remarks.
2486	Clark	3.102	4.067	2.140	0.250	0.169	0.080	0.127	trace.	0.598	88.946	2.025	0.807	0.434	10.30	Virgin soil, c'flsh l'd. m. H.
2486	Madison	5.683	5.588	4.173	.768	.478	.304	.427	0.065	1.126	81.802	2.350	1.867	.236	2.16	Upper soil } Upper Hudson.
2487	Madison	4.213	4.618	4.000	.612	.414	.251	.447	.072	.944	83.753	2.100	1.959	.367	1.71	Subsoil . }
2488	Madison	12.677	12.227	3.604	.073	.401	.235	.543	. . . .	2.248	68.034	4.834	1.365	.127	.55	Upper soil } Black shale.
2489	Madison	5.671	9.789	8.865	.073	.529	.072	.133	. . . .	1.657	72.504	2.585	1.722	.092	.91	Subsoil . }
2490	Madison	4.008	6.012	5.011	.508	.677	.128	.435	. . . .	1.058	82.040	2.615	1.964	.504	.21	Upper soil } Middle Hudson.
2491	Madison	3.554	6.295	5.484	.381	.462	.118	.491	. . . .	1.030	82.240	2.925	1.848	.281	.36	Subsoil . }
2492	Madison	3.874	5.171	4.337	.107	.242	.095	.344	. . . .	.926	84.468	2.300	3.463	.273	4.93	Upper soil } Black shale.
2493	Madison	3.678	4.990	3.792	.082	.265	.078	.312	. . . .	.628	86.185	2.135	1.897	.260	3.64	Subsoil . }
2494	Madison	2.971	3.830	3.245	.106	.300	.030	.242	. . . .	.634	88.756	1.550	1.935	.418	8.18	Upper soil } Wav'ley group.
2495	Madison	2.055	6.986	4.655	.052	.466	.040	.092	. . . .	.492	84.926	2.440	1.527	.541	12.13	Subsoil . }
2501	Montgomery	3.955	5.088	4.210	.482	.349	.193	.437	. . . .	.677	84.906	2.540	1.803	.372	4.50	Virgin soil, middle Hudson.
2502	Montgomery	3.387	6.120	4.370	.457	.410	.184	.405	.077	.658	84.209	2.760	1.925	.421	5.00	Subsoil of same.
2503	Montgomery	3.908	4.441	6.220	.365	.351	.309	.399	.124	.632	83.212	2.785	1.853	.489	1.90	Old field soil, same locality.
2504	Montgomery	3.208	7.037	4.870	.305	.393	.238	.432	. . . .	.688	82.733	3.370	1.837	.414	6.00	Subsoil of the same.
2505	Montgomery	5.495	4.885	4.365	.622	.532	.315	.256	.265	1.425	82.284	2.825	1.629	.323	1.17	Virgin soil, upper Hudson.
2506	Montgomery	4.092	7.992	5.568	.718	.538	.261	.610	. . . .	1.176	78.883	3.250	1.444	.277	.38	Subsoil of same.
2507	Montgomery	5.160	5.597	4.540	.400	.229	.260	.335	.276	1.382	82.121	2.425	1.189	.239	2.01	Old field soil, same locality.
2508	Montgomery	3.816	5.473	5.360	.319	.178	.157	.526	.279	1.246	83.169	2.915	1.105	.206	1.71	Subsoil of same.
2517	Rockcastle	2.704	5.283	2.332	.081	.127	.045	.290	. . . .	.339	88.469	1.175	.570	.115	4.04	Upper soil { Conglomerate
2518	Rockcastle	3.414	2.308	1.392	trace.	.045	.056	.345	. . . .	.217	92.499	1.210	.810	.137	1.73	Subsoil . } formation.
2519	Rockcastle	3.178	7.094	3.534	.112	.183	.056	.211	. . . .	.840	83.951	1.675	.259	.040	3.32	Upper soil { St. Louis lime-
2520	Rockcastle	4.505	11.403	5.090	.077	.185	.033	.345	. . . .	.808	77.028	2.900	.243	.097	4.49	Subsoil . } stone.
2524	Florida	1.075	.395		.095	.060	n. e.	.100	.138	n. e.	98.995	n. e.	n. e.	n. e.	. . . .	Orange county, surface soil.
2525	Florida	.550	.425		.070	.053	n. e.	n. e.	n. e.	n. e.	99.045	n. e.	n. e.	n. e.	. . . .	Orange county, subsoil.

TABLE II.—COALS. (AIR-DRIED.)

Number	County.	Specific gravity.	Hygroscopic moisture	Volatile combustible matters	Coke	Total volatile matters	Carbon in the coke	Ash	Character of the coke	Color of the ash	Per cent. of sulphur	Remarks.
2462	Carter	1.256	0.90	56.56	42.60	57.40	35.06	7.54	Dense friable	Brownish-grey	2.200	Cannel coal, Hyston br. of little f. of little Sandy.
a2460	Butler	1.221	8.60	34.36	57.64	42.36	54.24	3.40	Spongy	Light buff-grey	.876	Mining City. (Bed 4 feet thick.)
a2478	Harlan	1.264	2.00	35.60	61.80	38.20	58.60	3.20	Dense spongy	Lt. purplish-grey	.491	R. fork of Clover cr. Cumb. riv. up'r coal meas'rs.
b2478	Harlan	1.198	1.10	35.34	63.20	36.80	61.80	1.40	Dense spongy	Lt. purplish-grey	.497	Looney cr. of Rock f. of Cumb. riv. up. coal meas.
c2478	Harlan	1.307	2.20	35.10	62.70	37.30	56.70	6.00	Spongy	Grey-buff	.818	Head waters Wallen's creek, Cumberland river.
2482	Lawrence	1.424	.40	31.60	68.00	31.40	50.04	17.96	Friable	Lt. yellowish grey	.642	Richardson coal, on Nat's creek, upper 3 feet.
2483	Lawrence	1.408	.40	30.80	68.80	31.20	48.50	20.30	Dense	Lt. purplish-grey	.821	Richardson coal, on Nat's creek, lower 3 feet.
a2483	Letcher	1.278	2.50	30.94	66.56	33.44	57.75	8.81	Dense	Light grey-buff	.629	On Roberts' br. Pcor f. of Cumb. riv. upper part.
b2483	Letcher	1.225	2.05	33.18	64.76	35.24	50.26	5.50	Spongy	Light grey-buff	7.90	On Roberts' br. Pcor f. of Cumb. riv. lower part.
2509	Morgan	1.253	1.40	50.06	48.54	51.46	40.14	8.40	Dense	Grey-brown	1.650	Cannel coal, Elk fork of Licking river.
2511	Pike	1.294	.40	32.20	66.40	33.60	62.46	3.94	Dense spongy	Lt. salmon-grey	.642	Big Rock Hollow of Bear f. of Robinson creek.
2512	Pike	1.273	.40	34.80	64.80	35.20	60.46	4.34	Spongy	Salmon colored	.711	Same location, lower twenty-five inches.
2513	Pike	1.310	1.60	30.80	67.60	32.40	62.80	4.80	Dense	Dark salmon col'd	.555	Big Rock Fork of Bear creek.
2514	Pike	1.293	2.00	43.40	54.60	45.40	46.30	8.30	Pulverulent	Salmon colored	.689	Cannel coal, Bear Fork.
2415	Pike	1.294	.00	33.94	65.46	31.54	59.46	6.00	Light spongy	Reddish grey	.876	Left Fork Indian creek, Hall's bank.
2516	Pike	1.311	1.60	31.20	64.80	35.20	58.90	5.90	Spongy	Grey	.903	Robinson creek, Jackson Newson's bank.
2526	Whitley	1.286	1.60	32.86	65.20	34.76	63.10	2.11	Spongy	Lt. brownish-grey	.700	Mt. Jellico Coal & Coke Co.'s main coal.

TABLE III.—COKES. (AIR-DRIED.)

Number	County.	Moist'e and volatile matters	Carbon in the coke	Ash	Color of the ash	Percentage of sulphur	Remarks.
2177	Floyd	0.00	94.70	4.70	Reddish brown	0.835	Coke of Judge Layne's coal bed. (Forty-two hours in oven.)
2179	Hopkins	1.70	81.10	17.20	Purplish grey	4.350	Of Crab Tree coal slack (coal No. 12.)
2180	Laurel	1.60	92.20	6.20	Light grey	1.000	Of coal of lowest bed of coal measures, from Pitmam's Station. (Sixty-six hours in oven.)
2181	Laurel	1.20	89.80	8.90	Reddish brown	1.274	Of coal same bed and locality. (Coked forty-two hours.)
2510	Muhlenberg	1.50	90.54	7.96	Purplish brown	2.469	Of coal No. 9. (Coked forty-eight hours.)
2523	Whitley	2.00	94.80	3.20	Light brick color	.849	Of coal from near Mahon Station. Knoxville branch L. & N. railroad.

TABLE IV.—CLAYS. (AIR-DRIED.)

Number	County.	Silica	Alumina	Iron Peroxide	Lime	Magnesia	Potash	Soda	Carb. acid, water and loss, etc.	Remarks.
2463	Carter	43.58	40.86	0.76	0.29	0.14	0.19	0.05	14.13	Fire clays from Perry's branch of Tygart's creek; Tygart Valley Mining Company.
2464	Carter	44.84	40.18	1.76	.21	.13	.17	.06	12.65	
2465	Carter	41.28	40.56	4.42	.60	.17	.11	trace	12.86	
2466	Carter	41.58	38.38	4.04	.21	.10	trace	trace	15.69	
2467	New Jersey	39.760	42.850	.940	.398	.650	.477	. . . .	14.640	Celebrated Woodbridge fire clay.
2496	Madison	50.000	20.680	3.960	1.456	1.096	5.500	.217	8.091	Shaley clay on Niagara shale, *upper* 10 inches.
2497	Madison	42.560	20.080		8.680	7.247	4.819	.166	15.548	Shaley clay, lower ten inches.
2498	Madison	48.000	18.380	3.900	1.600*	4.033*	3.797	.276	20.014	Plastic clay on Waverly Gr. near conglomerate.
2499	Madison	49.689	19.026	3.932	.927	1.960	3.827	.288	17.410	Same clay calculated dried at 212° F.
2522	Whitley	54.180	25.360	4.820	.649	1.614	4.286	.348	9.800	Bituminous indurated clay.

* Estimated as carbonates.

TABLE V.—MARLY CLAYS AND SHALES. (AIR-DRIED.)

Number	County.	Silica	Alumina	Iron peroxide	Carbonate of Lime	Carbonate Magnesia	Phosphoric acid (P_2O_5)	Potash	Soda	Water, loss, etc.	Remarks.
2460	Breckinridge	73.500	16.760		0.280	1.892	n. e.	2.085	0.034	5.449	Marly shale from Buffalo Licks.
2461	Carter	58.440	13.375	5.000	13.880	3.420	0.205	3.020	.282	2.378	Marl. (Carter County Limestone Marl Company.)
2499	Madison	68.440	20.180		.145	2.880	trace	3.678	.740	3.977	Marly shale, four miles south of Berea.

TABLE VI.—LIMESTONES. (AIR-DRIED.)

Number	County.	Lime carbonate	Magnesia carbonate	Alumina	Iron peroxide	Phosphoric acid (P_2O_5)	Potash	Soda	Silicious residue	Water and loss	Remarks.
52460	Caldwell	97.040	1.180	. . . .	0.280	trace	n. e.	n. e.	1.160	. . . .	Oolitic, bed ten to twelve feet, four miles east of Princeton.
2469	Clark	21.380	3.055	n. e.	n. e.	9.710	0.830	0.228	27.580	n. e.	Phosphatic limestone. Oriskany limestone, (hydraulic?)
2470	Clark	33.980	11.185	n. e.	. . . .	1.842	n. e.	n. e.	31.720	n. e.	Phosphatic limestone. Oriskany limestone, (hydraulic?)
52475	Fayette	n. e.	n. e.	n. e.	n. e.	3.880	n. e.	n. e.	n. e.	n. e.	Phosphatic limestone. Trenton limestone.
c2475	Fayette	. . . .	. . . .	. . . .	. . . .	3.487	. . . .	. . . .	. . . .	. . . .	Phosphatic limestone. Trenton limestone.
2476	Franklin	. . . .	. . . .	. . . .	. . . .	4.029	. . . .	. . . .	. . . .	. . . .	Phosphatic limestone. Trenton limestone.
2478	Harlan	50.000	1.820	4.300			n. e.	n. e.	17.740	16.640	Bituminous limestone. (1.38 per cent. soluble silica.
2484	Lewis	48.700	37.432	2.490		.143	.490	.058	10.00	.547	Hydraulic limestone. (1.15 per cent. of soluble silica.)
2485	Lyon	85.580	2.088	.680			.251	.178	9.580	1.643	Bituminous limestone. Col. Machen's
2500	Montgomery	n. e.	n. e.	n. e.	n. e.	.473	n. e.	n. e.	n. e.	n. e.	Phosphatic limestone. Aaron's Run.

SUPPLEMENT

TO THE

APPENDIX TO THE SIXTH CHEMICAL REPORT OF THE NEW SERIES,

Containing Analyses of Coals and Cokes of Recent Collection.

[N. B.—The numbers follow in regular succession and the names of the counties in alphabetical order.]

BREATHITT COUNTY.

No. 2527—"COAL: *G. W. Nobles, on Lost creek of Troublesome creek. Collected by J. M. Hodge, February, 1885. Sample of the solid outcrop.*" *Breathitt county.*

A pure-looking, pitch black coal. Fracture mostly irregular and shining. Very little fibrous coal apparent in it. No appearance of pyrites.

No. 2528—"COAL: *Bank at the mill, Lost creek, on Troublesome.*" *Breathitt county. Collected by J. M. Hodge, February 3, 1885.*

A pure-looking, rather dull black coal; generally breaking in irregular laminæ, with some little fibrous coal between, but no apparent pyrites, some portions breaking with irregular, shining fracture.

No. 2529—"COAL: *Gough & Company, on Kentucky river, near the head of Big Branch.*" *Breathitt county. Collected by J. M. Hodge, February, 1885.*

Resembles the next preceding.

No. 2530—"COAL: *Absalom C. R. Russell, Russell branch of Troublesome creek." Breathitt county. Collected February, 1885, by J. M. Hodge. Sample from the solid outcrop.*

Seems to be a weathered sample. In rather thin, irregular laminæ, with ferruginous stains on some exterior surfaces.

No. 2531—"COAL: *Jacob Rolbey's, on Russell branch of Troublesome creek. Breathitt county. Sample from the soft outcrop. Bed sixteen inches thick." Collected by J. M. Hodge, February, 1885.*

A weathered sample of what seems to be splint coal. Somewhat soiled with dirt.

COMPOSITION OF THESE BREATHITT COUNTY COALS.

(*Air-dried.*)

	No. 2527	No. 2528	No. 2529	No. 2530	No. 2531
Specific gravity	1.363	1.366	1.362	1.345	1.426
Hygroscopic moisture	1.40	1.40	1.74	3.80	4.20
Volatile combustible matters	33.90	35.90	34.06	35.60	32.40
Coke	64.70	62.70	64.20	60.60	63.40
Total	100.00	100.00	100.00	100.00	100.00
Total volatile matters	35.30	37.30	35.80	39.40	36.60
Fixed carbon in the coke	51.90	52.50	53.80	54.80	52.26
Ash	12.80	10.20	10.40	5.80	11.14
Total	100.00	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Spongy.	Spongy.	Dense.	Dense friable.
Color of the ash	Dark grey.	Dk. purplish g'y.	Light grey.	Salmon-colored.	Very l'ht grey.
Percentage of sulphur	3.156	3.483	1.808	0.875	0.848

With the exception of No. 2530, these coals leave rather more than the average proportion of ash, and Nos. 2527 and

2528 contain a pretty large amount of sulphur, although there was no appearance of pyrites (iron bi-sulphide) in the samples and but little fibrous coal. This does not prevent the profitable uses of these coals for ordinary purposes. The weathered samples, Nos. 2530 and 2531, have probably lost much of their original sulphur by the process of weathering, in which it has been oxidated and washed out. It is probable, also, that samples taken deeper in the bed, where the coal has not been weathered, the proportion of ash will be found to be notably less than in these outcrop samples.

LESLIE COUNTY COALS.

No. 2532—COAL: "*Archibald Cornett's, Laurel Fork of Cutshin creek, Leslie county. Sample from the upper and lower seams of the solid outcrop.*" *Collected by J. M. Hodge, February, 1885.*

A portion of the sample has irregular laminated structure, showing very little fibrous coal and no apparent pyrites; another portion breaks with irregular fracture and shining surfaces; is pitch black and pure-looking.

No. 2533—COAL: "*Archibald Cornett's. Same locality as the next preceding. Sample from the middle, bituminous portion.*" *Collected by J. M. Hodge, February, 1885.*

Mostly a pure-looking, pitch-black coal, breaking, generally, with irregular, shining fracture. Some portions are irregularly laminated and more dull in appearance. Very little fibrous coal and no pyrites apparent.

No. 2534—CANNEL COAL: "*Archibald Cornett's. From the same locality as the preceding samples. Sample from the solid outcrop.*"

A very tough, dull-black coal. Fracture very flat, imperfect conchoidal. No apparent fibrous coal or pyrites. Some parts of the sample somewhat soiled with clay.

No. 2535—COAL: *"John Lewis', Cutshin creek. Sample from the solid outcrop of the five-feet bed." Collected by J. M. Hodge, February, 1885.*

A portion of the sample is in pure-looking, pitch-black fragments, breaking irregularly, with shining surfaces; another portion is dull-black and irregularly laminated. Very little fibrous coal and no pyrites apparent.

No. 2536—COAL: *"J. Pennington's, Cutshin creek. Sample of the outcrop of the lower bed. Collected by J. M. Hodge, February, 1885.*

A much weathered and soiled sample of what looks like a bituminous shale.

COMPOSITION OF THESE LESLIE COUNTY COALS.

(*Air-dried.*)

	No. 2532	No. 2533	No. 2534	No. 2535	No. 2536
Specific gravity	1.248	1.243	1.255	1.319	1.595
Hygroscopic moisture	1.80	1.60	0.60	2.00	2.20
Volatile combustible matters	34.60	32.06	45.30	31.00	26.14
Coke	63.60	66.34	54.10	67.00	71.66
Total	100.00	100.00	100.00	100.00	100.00
Total volatile matters	36.40	33.66	45.90	33.00	28.34
Fixed carbon in the coke	57.70	61.24	47.20	59.94	32.06
Ash	5.90	5.10	6.90	7.06	39.60
Total	100.00	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Spongy.	Dense.	Spongy.	Pulverulent.
Color of the ash	Brown grey.	Lt. bro'n grey.	Lt. bro'n grey.	Nearly white.	Very lt. grey.
Percentage of sulphur	1.055	0.737	0.683	0.665	0.519

Nos. 2532 and 2533 appear to be quite good coals, with

rather small proportions of ash and not much sulphur. As they are from the outcrop, it is probable that the coal further in the bed will be found to be purer than these samples. No. 2534 contains quite a moderate quantity of ash for a cannel coal, and this may be found to be less in the interior of the bed, where the coal has not been weathered. The value of the bed, however, depends greatly on its thickness, which is not stated in the label. No. 2535 is also a weathered sample, as its considerable proportion of moisture indicates. No doubt it gives more ash than will be found in the unweathered coal. No. 2536, with its very large proportion of ash, seems to be only a Bituminous shale, but as it contains about 58. per cent. of combustible matters, it may be useful as fuel, in the vicinity of the bed, in some cases. Possibly it may be found with less ash in the interior of the bed.

LETCHER COUNTY COAL.

No. 2537—COAL: "*Hardin Sparkman's. Head of Line Fork, Letcher county. Sample of the muddy outcrop of the sixty-two-inch bed.*" *Collected by J. M. Hodge, February, 7, 1885.*

A pure-looking, pitch-black coal. Fracture generally irregular; some portions in irregular laminæ. No appearance of pyrites and very little of fibrous coal.

COMPOSITION, AIR-DRIED.—SPECIFIC GRAVITY = 1.321.

Hygroscopic moisture	3.06	Total volatile matters	= 36.60
Volatile combustible matters	33.54		
Dense coke	63.40	Fixed carbon in the coke	= 59.20
		Salmon-colored ash	= 4.20
	100.00		100.00

Its percentage of sulphur is = 0.547.

This appears to be a remarkably pure and good coal. It is probable that deeper in the mine, beyond the weathered outcrop, the proportion of its ash may be somewhat smaller, while its sulphur percentage may be slightly larger.

HARLAN COUNTY COAL.

No. 2538—COAL: "*On Half-mile branch of Greasy creek, Harlan county. A thirteen-foot bed, with partings. The sample taken from the fourteen, twenty-one, and thirty-inch seams of the muddy outcrop.*" *Collected by J. M. Hodge, February, 1885.*

COMPOSITION, AIR-DRIED.—SPECIFIC GRAVITY = 1.505.

Hygroscopic moisture	5.10	Total volatile matters	= 29.80
Volatile combustible matters	24.70		
Pulverulent coke	70.20	Fixed carbon in the coke	= 52.00
		Light-buff ash	= 18.20
	100.00		100.00

Its percentage of sulphur is = 0.725.

No doubt this coal will be found to give less ash deeper in the bed, where it has not undergone the process of weathering. But, even with its more than twenty-three per cent. of ash and moisture, it yet contains more than seventy-six per cent. of combustible matters, and hence it may be available for fuel, in many cases, in the vicinity of the mine.

PERRY COUNTY COALS.

No. 2539—COAL: "*Head of Leatherwood creek. Sample from the lower three and a half feet of the five-and-a-half-foot bed.*" *Collected by J. M. Hodge, February, 1885.*

A pretty pure-looking sample. Breaking into thin, irregular laminæ, with some fibrous coal apparent, but no pyrites visible.

No. 2540—COAL (CANNEL): "*B. F. Grigsby's, right fork of Lot's creek.*" *Collected by J. M. Hodge, February, 1885.*

A pure-looking Cannel Coal. Tough. Fracture very broad, irregular conchoidal.

No. 2541—COAL: "*Fielding Comb's opening, Dark Fork of Lot's creek. Sample from the outcrop of the four-foot bed.*" *Collected by J. M. Hodge, February, 1885.*

A much weathered sample of what appears to be a splint coal.

No. 2542—COAL: "*Henry Engle's bank, Combs' branch of Troublesome creek. Sample from the bottom of the bed. Solid outcrop.*" *Collected by J. M. Hodge, February 7, 1885.*

A pure-looking coal, generally. Portions irregularly laminated, with a little fibrous coal, but no apparent pyrites between. Other portions break with irregular cuboidal fracture and shining, irregular surfaces.

No. 2543—COAL: "*Henry Engle's bank, Comb's branch, etc., etc. Sample from the outcrop of the upper two seams of the bed.*" *Collected by J. M. Hodge, February, 1885.*

A much weathered and soiled sample of what seems to be a splint coal.

No. 2544—COAL: "*Elijah Cornett's, on the Kentucky river, three miles above Hazard, Perry county. Sample from the upper bed.*" *Collected by J. M. Hodge, February, 1885.*

A somewhat weathered sample of splint coal. Some fibrous coal, but no pyrites apparent between the laminæ.

No. 2545—COAL: "*William Sheppard's opening, Oldhouse Branch of Leatherwood creek. An average sample from the upper seventeen inches.*" *Collected by J. M. Hodge, February, 1885.*

A weathered sample of what appear to be bituminous and splint coals, which seem to be pretty pure.

No. 2546—COAL: "*From the thirty-three-inch bed worked at Hazard.*" *Collected by J. M. Hodge, February, 1885.*

A pure-looking, pitch-black coal. Fracture generally irregular and semi-cuboidal, with bright, shining surfaces. Some portions laminated, with some fibrous coal, but no pyrites apparent.

No. 2547—COAL: "*Andrew Shepherd's, Stony fork of Leatherwood creek.*"

A small sample of pitch-black, pure-looking coal. Fracture irregular. No fibrous coal or pyrites apparent.

(The sample was so small that it may be doubted whether it represented the average of the bed.)

COMPOSITION OF THESE PERRY COUNTY COALS, AIR-DRIED.

	No. 2539	No. 2540	No. 2541	No. 2542	No. 2543	No. 2544	No. 2545	No. 2546	No. 2547
Specific gravity	1.799	1.250	1.570	1.338	1.356	1.381	1.362	1.287	1.276
Hygroscopic moisture	1.40	0.44	5.20	1.50	3.00	4.50	1.40	1.50	1.44
Volatile combustible matters	28.20	44.16	31.86	31.56	32.80	32.50	28.60	33.50	38.06
Coke	70.40	55.40	62.94	66.94	64.20	63.00	70.00	65.00	60.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	29.60	44.60	37.06	33.06	35.80	37.00	30.00	35.00	39.50
Fixed carbon in the coke	53.90	49.40	52.94	56.54	56.14	57.50	58.00	61.20	54.90
Ash	16.50	6.00	10.00	10.40	8.06	5.50	12.00	3.80	5.60
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Dense.	Dense spongy.	Pulverulent.	Light spongy.	Pulverulent.	Pulverulent.	Dense.	Light spongy.	Dense.
Color of the ash	Very l't. grey.	L't grey-brown.	Very light buff	White.	L't grey-brown.	Nearly white.	Very l't grey.	Very l't grey.	Nearly white.
Percentage of sulphur	0.978	0.766	0.588	0.849	1.316	0.670	0.958	0.794	0.972

In the foregoing table it can be seen that coals numbered 2539, 2541, 2542, and 2545 exceed the average in their proportions of ash, varying from 16.50 per cent. in No. 2539 to 10 per cent. in No. 2541; yet all of these may be valuable for fuel if there is no competition of purer coals. Some of these samples, however, were of the weathered outcrops, and the coals, deeper in the beds, may very probably be found to be purer. The largest proportions of volatile combustible matters are found in the Cannel Coals, Nos. 2540 and 2547, and the greatest amount of fixed carbon in the coke is in No. 2546, which, especially as it leaves but a very small proportion of ash and contains only a moderate quantity of sulphur, would be the best coking coal of all these now reported from this county.

WOLFE COUNTY COALS.

No. 2547 (*bis.*)—COAL: "*J. M. Cockerham's (Hobbs' Coal), on Devil's creek, Wolfe county.*" *Collected by J. M. Hodge, February, 1885.*

(The whole bed is eighty-one inches thick, in which there are four several layers of coal, aggregating sixty-one inches; and three partings of combined thickness of twenty inches.)

No. 2548—"*Sample from the upper, twenty-four-inch layer of the coal.*"

Mostly bright, pitch-black coal. Of irregular fracture, with shining surfaces. Some portions are tougher, breaking into irregular laminæ, with some little fibrous coal, but no apparent pyrites between.

No. 2549—"*Sample from the middle portion of the bed.*"

This contains more of the laminated or splint coal than the preceding, and rather more fibrous coal.

COMPOSITION OF THESE WOLFE COUNTY COALS.

(*Air-dried.*)

	No. 2548	No. 2549
Specific gravity	1.266	1.282
Hygroscopic moisture	4.70	8.40
Volatile combustible matters	33.56	37.50
Coke	61.74	59.10
Total	100.00	100.00
Total volatile matters	38.26	40.90
Fixed carbon in the coke	59.14	55.70
Ash	2.60	3.40
Total	100.00	100.00
Character of the coke	Spongy.	Spongy.
Color of the ash	Nearly white.	Very l't purp. g'y
Percentage of the sulphur	0.574	0.895

These are very good and pure coals, and, no doubt, are suitable for the manufacture of coke.

COKES OF THESE WOLFE COUNTY COALS.

No. 2550—"*Coke, made from a sample of the coal No. 2548.*" *Collected by J. M. Hodge, February, 1885.*

A light, spongy coke.

No. 2551—"*Coke, made of the softer and brighter part of sample No. 2549.*" *Collected by J. M. Hodge.*

No. 2552—"*Coke, made of the splint portion of coal No. 2849.*"

COMPOSITION OF THESE COKES.

(*Air-dried.*)

	No. 2550	No. 2551	No. 2552
Moisture given off at 212° F.	4.00	3.90	2.96
Volatile matters given off at red heat	1.00	.50	1.44
Fixed carbon	89.20	90.00	91.00
Ash	5.80	5.60	4.60
Total	100.00	100.00	100.00
Color of ash	Light grey.	Salmon-colored.	Light grey.
Percentage of sulphur	0.505	0.576	0.503

These all have the composition of remarkably good and pure cokes.

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